WORLD OIL

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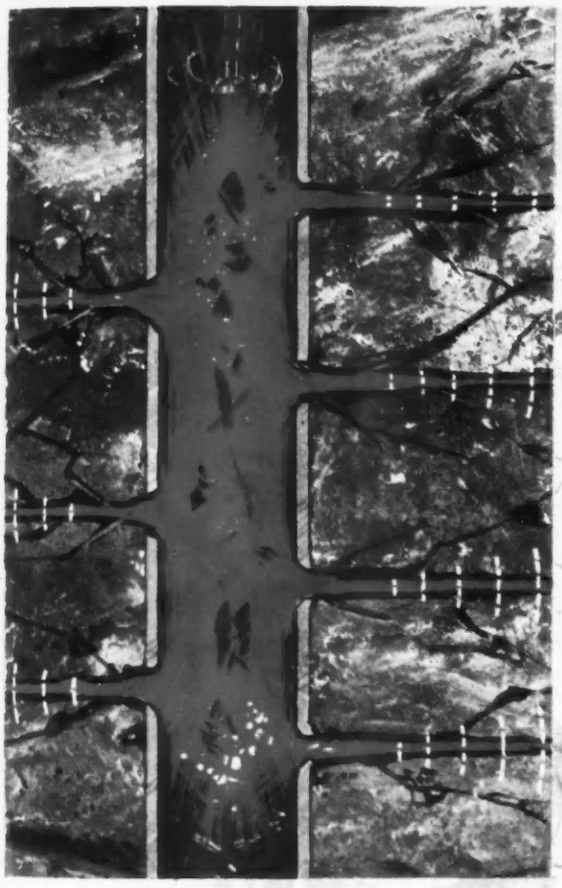

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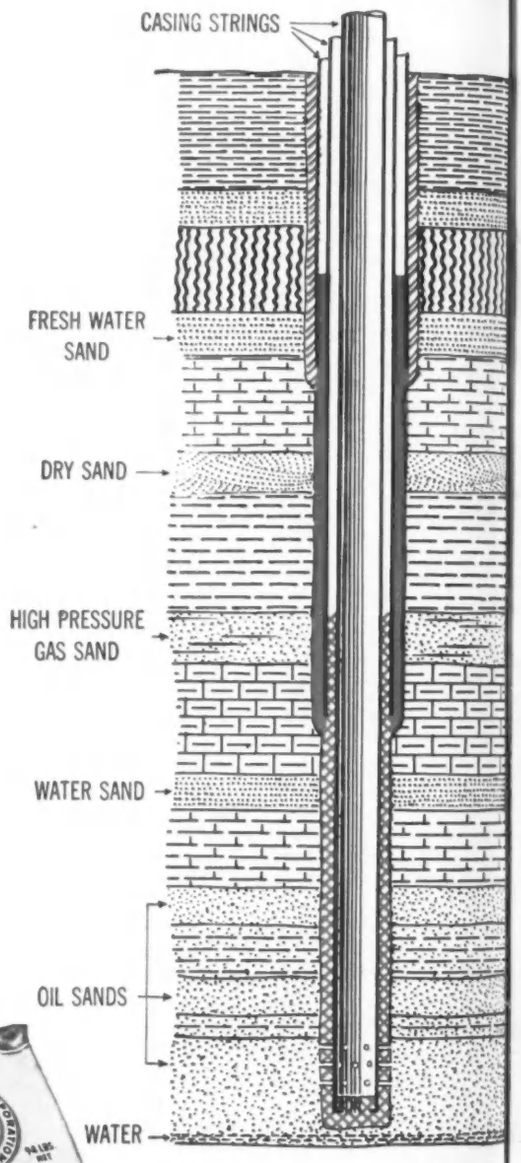

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VOLUME 147, NO. 6 NOVEMBER, 1958

WORLD OIL

SPECIALIZED FOR EXPLORATION, DRILLING AND PRODUCING OPERATIONS AND MANAGEMENT

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Watch for World Oil's centennial issue
a CENTURY OF OIL . . . January 1, 1959

a *Quick Look* at WORLD OIL this month

BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first.

What's ahead for '59

☐ Some increase in drilling is indicated for 1959, although field activity may not expand materially until next spring. More crude production and more drilling will be required in meeting demand for petroleum, which will improve further as business recovery proceeds. In the next three months total demand for oil is expected to be 3.8 percent greater than a year ago. Domestic crude needed will average 7 million barrels daily. Actual production was 125,000 barrels short of that in October but will be stepped up about 60,000 in November. . . . . **Page 13**

Price cuts darken outlook

☐ The U. S. oil industry during October continued to be plagued by depressing trends. Despite a favorable turn in the industry's statistical position, additional price cuts on crude oil, gasoline and residual fuels took place. Major factor behind crude price adjustments is the downward trend in gasoline prices. Demand situation in coming months look better. But only time will tell if higher winter demand will stop downward trend of prices. . . . . **Page 25**

New completions steady

☐ New well completions in September totaled 4,134, compared to 4,016 in August and July's 4,143. Total for first nine months of 1958 is 35,647, indicating WORLD OIL's forecast of 47,952 for year will be reached. Activity may pick up as oil companies push to complete drilling programs within calendar year. For details, turn to . . . . . **Page 28**

WORLD OIL, published every month except semi-monthly in February and August. Entered as THE OIL WEEKLY as second class mail matter December 23, 1916, at post office at Houston, Texas, under the act of March 3, 1879.

☐ **An independent's blueprint for survival** . . . Independents have been telling everyone who will listen that their road is rocky and rough, and seems to be heading for oblivion. This is not necessarily true. Every independent operator and every major oil company official should read this timely, candid evaluation by Independent Michel T. Halbouty of some of the most pressing problems confronting the U. S. Oil industry today . . . . . **Page 103**

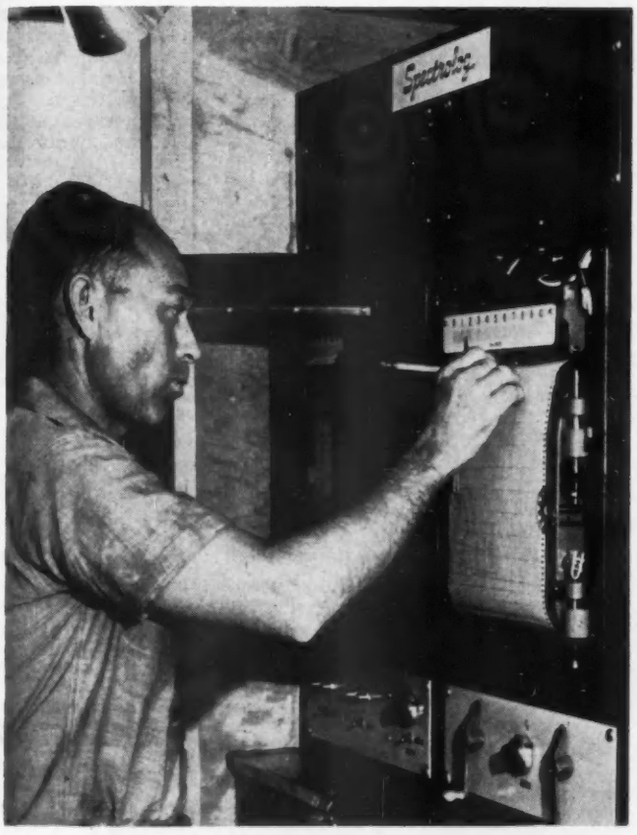
☐ **Economics of secondary recovery in Montana** . . . Increased reserves of 96 percent would result from the successful application of secondary recovery methods in Montana. The economic significance, prospects, and recommended areas and methods of this technique are discussed in this article. . . . . **Page 107**

☐ **New look at salt dome geology** . . . A modified theory of salt movement in the Gulf Coast salt dome province may result in a revision of exploratory drilling procedures now used to investigate salt domes. . . . . **Page 111**

☐ **Uncontrolled directional drilling** . . . Faster penetration rates, less rig time and lower costs to operator and contractor have resulted from the successful use of uncontrolled directional drilling in Grady and Stephens counties, Oklahoma. Surface locations are offset so that normal drilling deviation of about 1 degree per 1,000 feet puts the bottom-hole location in a predetermined target area. . . . . **Page 115**

☐ **Nomograph for calculating recoverable oil reserves** . . . Here is an accurate, straightforward oil reserve nomograph. Each factor involved in the construction of this nomograph is discussed thoroughly. Current methods used to obtain these factors are explained. The method is applicable to over-all evaluation of an oil-producing property. . . . . **Page 119**

☐ **Wedging does make a difference** . . . Fault wedging is important when calculating reservoir volumes. A volumetric interpretation of a sand wedge against a fault in the Cibicides sand in the South Bell City field, Calcasieu Parish, Louisiana, is one of the highlights of this issue. . . . . **Page 130**



☐ **Improved logging methods reveal productive zones** . . . Qualitative and quantitative analysis of the gas, gas-condensate, oil and water-bearing formations now is possible with modern equipment used in spectrographic mud logging. Description of the methods of logging with the results of these logs, along with illustrations of the equipment and recorded data, are included in this article. . . . . **Page 125**

☐ **How to determine actual power output and derating factor** . . . Electric motors that drive pumping units must be derated if they are to be operated without being thermally overloaded. A method exists for determining actual power output and derating factors for these motors. Proper application of readily obtainable field data can lead to reduced investment costs of such installations. . . . . **Page 133**

☐ **This character with the camera in his cranium** is well on his way down one of the roads to failure. There are others. And this tongue-in-the cheek expose gives you a searching insight into the "man most likely to fail." There are some tried-and-true methods that will assure you of being a resounding flop.

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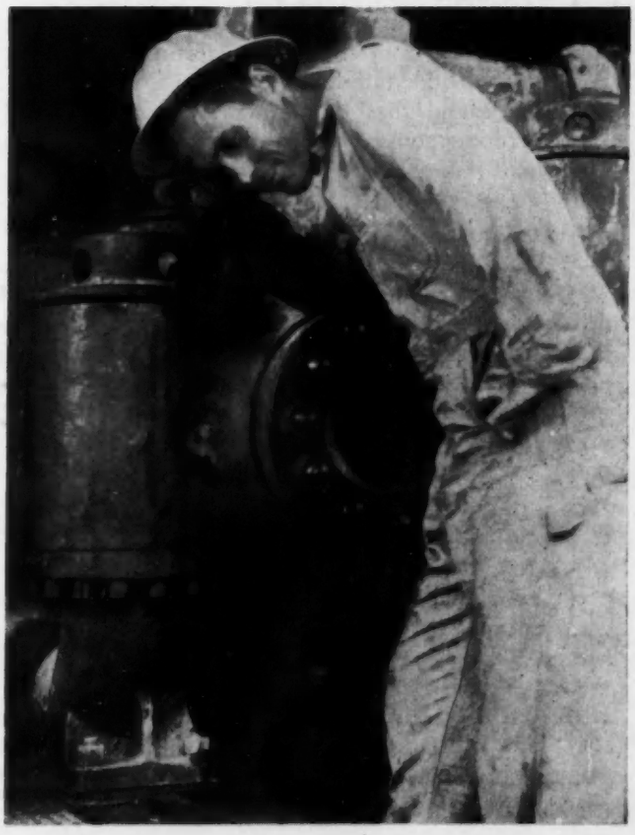
☐ **Using a wrench as a stethescope** is one way to localize a mud pump noise. Mud pump noises must be recognized and corrected. The noises are noticeable but the corrective measures are not always



THIS MONTH . . . *continued*

so obvious. The fifth part of this informative series—Know Your Mud Pump—tells how to recognize different noises and how to correct them. . . . . **Page 143**

☐ **Calculate recovery data from a gas reservoir.** This installment of a popular series for your production file tells how to determine by the material balance method:

- Data on gas produced when reservoir pressure declines to a given value,
- Cumulative gas recovery at abandonment,
- Recovery efficiency. . . . . **Page 147**

☐ **New developments in gyp muds** . . . Gypsum muds in the past have not been universally accepted because muds with high gel strength characteristics have prevented their use in areas requiring weighted muds. But with the advent of a new chemical material —ferrochrome lignosulfonate—gypsum muds now are applicable over a greater range of drilling conditions. **Page 138**

☐ **The subsurface Ouachita structural belt in Texas** . . . Virtually untested are the oil and gas possibilities of foreland facies rocks involved in frontal structures of the Ouachita belt. The subsurface Ouachita structural belt in Texas consists of a frontal zone of unmetamorphosed folded and thrust-faulted rocks, intermediate zones showing incipient to weak metamorphism and an overthrust hinter zone of strongly sheared low-grade metamorphic rocks. . . . . **Page 141**

☐ **Hydraulic fracturing pays off in the Strawn** . . . A study of the effects of hydraulic fracturing on oil recovery from the Strawn formation in North Texas has provided interesting results. The U. S. Bureau of Mines found that ultimate primary recovery and average production rates were increased by fracturing. **Page 155**

☐ **Gas turbo-electric drives for drilling rigs** . . . The Russians claim to be near the field application stage in the development of gas turbo-electric drives for drilling rigs. With new equipment reaching the hardware stage, the Soviets hope to utilize the higher theoretical power efficiency of turbines for drives for rigs, both in conventional rotary and turbine drilling. The new equipment is expected to provide electric power for electrodrilling in certain non-electrified areas where electrodrills are said to be more efficient than other rig types. . . . . **Page 168**

☐ **Active oil exploration proceeding in Afghanistan . . .** Afghanistan's oil prospects are being surveyed actively by U. S., Russian and Swedish interests. A strong competition is developing between the U. S. and Russia in assisting this isolated Texas-size nation. The U. S. effort is hampered by difficulty in interesting private investigators in Afghanistan. Nevertheless exploration is moving ahead. . . . . **Page 175**

WORLD OIL

Ray L. Dudley, Founder, 1891-1957

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Indexed by Industrial Arts Index and Engineering Index

Looking Ahead

Orders for equipment picking up . . . Manufacturers of oil field equipment, as well as makers of other machinery, have been encouraged in recent months by slightly increasing orders. However, there is much room for improvement in equipment sales. Buying of new drilling rigs is discouraged by the large number of idle rigs. Active rigs in the U. S. have increased several hundred from last spring's low point to more than 4,100. But this is 700 rigs or 15 percent less than the 4,800 active rigs a year ago. No material increases in the current 4,100 active rigs and 4,100 well completions per month are likely before next spring.

It is indicated that U. S. well completions in 1958 will total about 48,000, an average of 4,000 per month. That will be about 5,400 wells or 10 percent less than the 53,400 completions in 1957. It will be 10,400 wells or 18 percent less than the all time record of 58,400 wells completed in 1956.

Increase in drilling in 1959 is indicated . . . It is quite likely that there will be some increase in drilling in 1959. Improving general business and increasing demand for petroleum products will require more U. S. crude production and more drilling.

As oil companies achieve larger sales volumes and earnings, they will have available more funds for drilling and buying new operating facilities.

Companies will be preparing budgets for 1959 during the coming weeks. Encouraged by current and prospective favorable business trends, they can be expected to plan relatively vigorous programs of capital expenditures.

Oil demand 3.8% above year-ago forecast . . . Total demand for petroleum in the three months, November-January, will average about 10,275,000 barrels daily. That will be 3.8 percent more than in the same months a year ago. This is forecast by Independent Petroleum Association of America.

Domestic consumption will average 10 million barrels daily, up 4.2 percent from a year ago. Exports will run 275,000 barrels daily, or about the same as a year ago. In recent months total demand has run from 2 to 4.5 percent above a year ago. Nearly all products have shown increases. Gasoline demand lately has been up about 4.5 percent.

More U. S. crude will be required . . . Domestic crude oil needed in November-January will average 7 million barrels daily, IPAA estimated. That would be about 125,000 barrels per day higher than both October output and production in November-January a year ago.

U. S. crude production will be increased moderately in November. Texas output is scheduled to be about 60,000 barrels a day higher. The state will again have 11 producing days in November's 30 days as it did in October's 31.

Imports in November-January will average 1,650,000 barrels daily, reports to the Texas Railroad Commission indicated. Production of natural gas liquids will average 825,000 barrels daily, IPAA estimated.

Continued on next page

LOOKING AHEAD *continued*

Price cuts show up weak spots in markets . . . Markets for some oil industry products and crudes have been unsteady, in spite of a generally improving supply-demand situation. Weaknesses in the markets have been attested by recent price cuts on gasoline and crude in some areas.

Wholesale prices of gasoline have been marked down in the Mid-Continent, the Middle West, and the Gulf Coast. In the Middle West the price cuts were blamed on oversupplies.

Certain crudes in Arkansas were cut by amounts varying from 5 to 15 cents a barrel at mid-October. In one field, for example, 39 gravity crude was cut 15 cents to $2.93 a barrel. Previously, some crudes in Oklahoma were similarly reduced. The cuts have been called adjustments reflecting current values of refined products.

Three medium heavy Venezuelan crude oils were reduced at mid-October by 5 to 14 cents per barrel. Similar reductions were made previously in prices of California heavy crudes and fuel oils.

Lower prices of residual fuel oils in the U. S. reflect increased competition of natural gas.

Business slower in Western Europe . . . Although the low point of the U. S. slump may have been passed, industrial activity may now be still sliding in Western Europe. Oil field equipment orders in the United Kingdom are down, relative to 1957 volume. Fuel oil markets in Western Europe were generally weak, and Middle East oil production, particularly in Saudi Arabia and Iran, was dropping late this past summer.

Shale oil will undersell overpriced imported oils . . , Abundant U. S. shale oil is of great significance. It is a potential competitive substitute for Middle East and other oils produced outside the U. S.

Middle Eastern and other countries are constantly demanding increased prices as well as greater profit participation. As those countries inevitably raise prices above certain levels, shale oil will undersell and replace their oil.

The U. S. then will have a profitable shale oil industry. This is a possibility foreseen by Fred L. Hartley, vice president, Union Oil Company of California, which has proved the value of Colorado shale oil in a pioneering plant.

Gas production mostly on its own . . . Only about one third of the gross production of gas in the U. S. originates from wells which also produce crude oil, according to Charles E. Webber, Sun Oil Company.

This proportion is expected to grow in the future, with more gas being produced from wells not yielding oil. More new gas is being found per foot of hole drilled than new oil. Many geological trends, neglected because recognized as primarily gas-bearing, will be drilled as markets for gas continue to expand.

Hikes in gasoline taxes considered . . . Failure of gasoline tax revenue to increase as usual in 1958 may cause increases in gasoline taxes in several states.

There was a rather sharp decline in the rate of increase in motor fuel consumption during 1958, with a consequent decrease in growth of tax collections on gasoline. Several states actually showed decreases from 1957, and many states barely broke even. The over-all increase was just a little over two percent.

Two states increased gasoline tax rates in 1958: Rhode Island 2 cents, and New Jersey 1 cent. Several interim legislative committees are discussing increases.

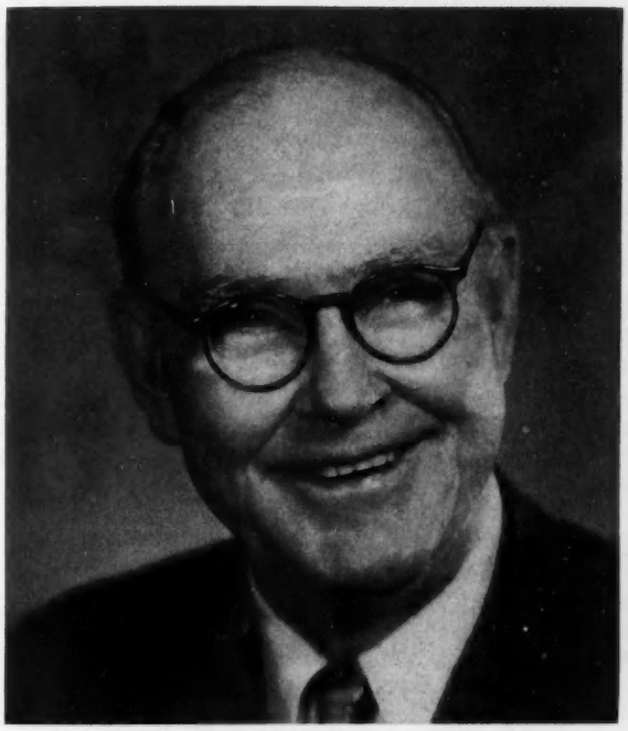
Space race to further strain supply of technicians . . . "This country is faced with a dangerous shortage of properly trained technicians to install, test, and maintain its burgeoning, vital systems of instrumentation . . . we do not begin to have enough skilled semi-professionals to service and efficiently operate these instruments and systems," according to Lloyd E. Slater, executive director, Foundation for Instrumentation Education and Research, New York City.

EDITORIAL PAGE

As a memorial on the first anniversary of his death, WORLD OIL publishes this editorial written in 1944 by its founder, Ray L. Dudley.

Although you may need to change some of the names, the dangers pinpointed in this editorial remain unchanged. And unaltered, too, remains the position of WORLD OIL and its publisher.

William Dudley



Ray L. Dudley 1891-1957

"So help me God"

I STOOD in the blazing sun at Ellington Field, in Texas, last Monday and watched the cadets file by, fine manly chaps, watched them come into the hall in which they were to receive their wings as commissioned officers in the United States Army Air Force. My third and last boy, a lad of 19, was among them.

Two years ago his mother and I had seen a similar group file into the chapel at Ellington to receive their wings, and our second boy was among them. Today he and his elder brother, who had chosen Navy Air, are memories, precious memories, it is true, but boys to be spoken of in hushed tones as boys who would have made good citizens, two boys whose memories will never be dimmed in the eyes of their father and mother. They, with thousands of others, have made the supreme sacrifice for America as they knew it and loved it.

Then Monday we heard again the prospective officers take the oath necessary to their commissions: *"I do solemnly swear that I will support and defend the constitution of the United States against all enemies, foreign or domestic, that I will bear true faith and allegiance to the same; that I take this obligation freely, without any mental reservation or purpose of evasion; and that I will well and faithfully discharge the duties*

EDITORIAL (Continued)

of the office upon which I am about to enter; SO HELP ME GOD."

For a moment my thoughts drifted from the son whose burned body lies somewhere in France and from the other son who lies in native soil . . .

Our forefathers who wrote the Constitution knew that they were giving to future generations a document so precious that it would be worth the loss of American lives to preserve . . . and they knew that there would arise enemies to it, *domestic* as well as foreign.

Then my mind went back to a time nearly three years ago, when my first two boys volunteered, and the pledge I made them then:

"To the best of my meagre ability I shall do all I can to defend against foes at home the institutions you boys have enlisted to uphold . . . and I shall do that without fear of sacrifice if it costs me everything I have, including my life, so help me God."

It was not necessary that I pledge them my fullest efforts to help prosecute the war . . . they could have expected no less of me as an American and a father.

The casualty lists over the country name thousands of parents whose boys have been lost and whose sons are as precious to them as mine were to me. I claim no distinction as the parent of boys who have died in the service. *I can only claim to be among those to whom this war is a deadly serious thing,* and I wish my claim to be listed among those who resent with every atom of their being, the efforts which are being made by the Hillmans, the Browders, the Murrays and others, including our President, to nullify the sacrifices of thousands of American boys.

As I heard the oath to defend the Constitution repeated by the young men at Ellington, I could not but remember the remarks which have been made about it by Americans of foreign birth who would seek to destroy it . . . "a scrap of paper . . . an outmoded document . . . a bill of property rights rather than a bill of human rights." And these are the men who are asking that we trust our country to them.

The situation under which the Communist Front in America is trying to wield control over our country through the capture of one of our great political parties, is so preposterous as to be almost incredible. But make no mistake—the threat is a real one. That a Russian-born radical, with all of the class hate of his native land should aspire to control this country is so fantastic that many cannot believe it. But it is true.

That he and his fellows have openly boasted that their organization, the CIO, is raising millions as a war chest to help keep Roosevelt in power, indicates a blatant confidence in their victory. That this money should be extracted from hundreds of thousands of members whose membership was forced on them, is a disgrace. That they get away with it is a shameful tribute to the close association they have with our Department of Justice.

Who was it who climbed the stairs, hat in hand, to Hillman's suite in a Chicago hotel to learn the wishes of the boss as to who would be Democratic candidate for the vice presidency? It was our United States Department of Justice head—the man sworn to uphold our laws (including the Smith-Connally act which makes it a felony for a labor party, or a corporation, to contribute to a political party). Yes, it was Attorney General Biddle, and the man with him was the person who later was named by Hillman as the Democratic vice presidential nominee, Harry Truman.

With Hillman and Browder and their ilk as arrogant as they are now, what will their attitude be if they succeed in re-electing Franklin D. Roosevelt? Where will their power end? What will happen to the rights guaranteed under our Constitution? If our interests should ultimately clash with those of Russia at what point will these men make up their minds as to where their first loyalty shall lie? If England's interests should clash with those of Russia, will our country's armed forces be thrown against a nation whose kinship to us derives from a common parenthood?

This is a long way from the ceremony at Ellington last Monday. The field has widened until the lives of a large group of fine boys seem but a drop in a great ocean.

But it is not a long way from the pledge I made my boys.

An editorial by the late Ray L. Dudley reprinted from The Oil Weekly (now WORLD OIL), October 9, 1944.

THE CHANGING PANORAMA

Warren L. Baker, Editorial Director

Price cuts darken outlook

Posting of lower prices for gasoline and crude oil despite favorable trends in stocks is the result of refiners' small margin of profit

Depressing trends continued to plague the U. S. oil industry during the past month. Additional price cuts on crude oil, gasoline and residual fuels took place, despite favorable trends in the industry's statistical position.

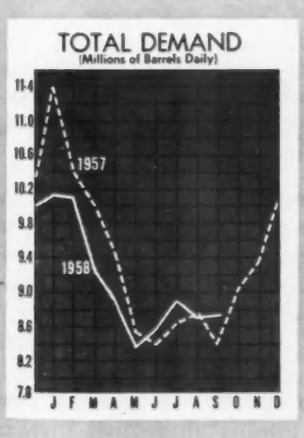
The latest adjustments in crude prices hit a sizable portion of the production in Oklahoma and North Texas, and were of sufficient size to create fear they might influence crude prices in adjacent competing regions. The new Oklahoma price for 40-gravity sweet oil is $3.01 cents a barrel, 14 cents under the level in January, 1958. This is 7 cents a barrel below West Texas 40 gravity crude, and only 1 cent above flat Illinois Basin prices.

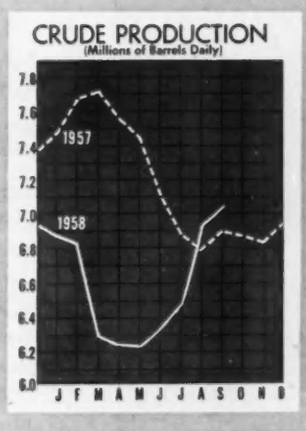
New prices for 20-gravity Oklahoma crude is $2.45 per barrel, 30 cents less than in January, 1958, and 5 cents below December, 1956. This is 23 cents less than West Texas 20-gravity crude prices, and 55 cents below the flat price for Illinois Basin oils.

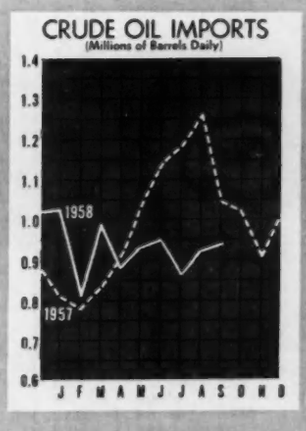
The major factor behind the new crude price adjustments is the downward trend in gasoline prices. This has caused refiners' profit margins to shrink sharply during the past year.

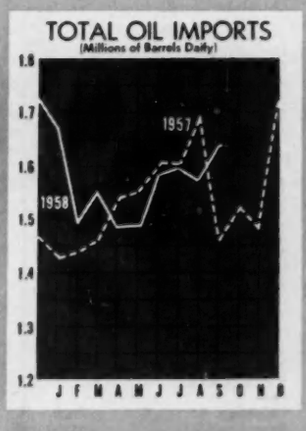
The outlook is darkened by further reductions in Midwest gasoline prices during the past month that ranged from 0.5 cents to 1.2 cents a gallon in various Midwest areas. Excessive

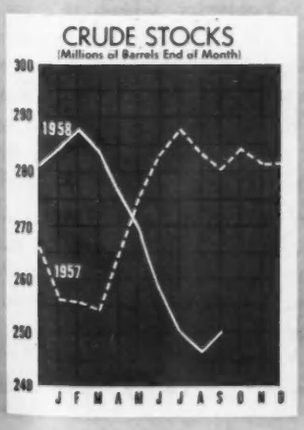
Petroleum Trends...

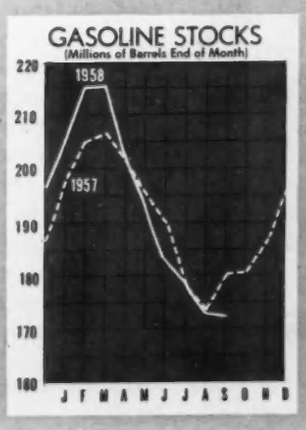


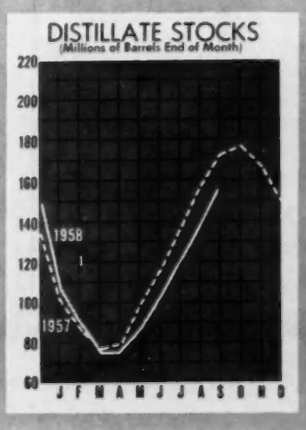


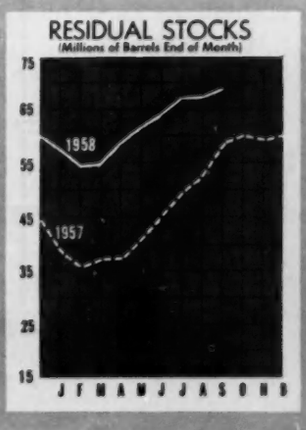












U. S. Monthly Oil Trends

(THOUSANDS OF BARRELS DAILY)

	SEPTEMBER			August 1958	JANUARY-SEPTEMBER		
	1958	1957	% Diff.		1958	1957	% Diff.
U.S. Crude Oil Production	7,056	6,887	+ 2.5	6,873	6,588	7,276	— 9.5
U.S. Nat. Gas Liquids Prod.	800	794	+ 0.8	790	782	802	— 2.5
U.S. Total Imports	1,643	1,459	+12.6	1,567	1,615	1,532	+ 5.4
East Coast Crude Imports	738	752	— 1.9	723	754	744	+ 1.3
Total Crude Imports	947	1,042	— 9.1	923	930	1,002	— 7.2
Total Refined Products	696	416	+67.3	644	685	531	+29.0
Total New Supply	9,499	9,152	+ 3.8	9,230	8,985	9,612	— 6.5
Stock Changes All Oils (Daily)	+750	+768	.....	+490	—96	+288	.....
Total Demand All U.S. Oils	8,749	8,383	+ 4.4	8,740	9,081	9,324	— 2.6
Gasoline Demand	4,140	3,896	+ 6.3	4,158	3,955	3,970	— 0.4
Distillate Fuel Demand	1,259	1,334	— 5.6	1,121	1,699	1,735	— 2.1
Residual Fuel Demand	1,258	1,252	+ 0.5	1,310	1,443	1,585	— 9.0
Domestic Demand, All Oils	8,449	8,049	+ 5.0	8,490	8,809	8,689	+ 1.2
Export Demand, All Oils	300	334	—10.2	250	273	635	—57.0
Crude Runs U.S. Refineries	7,703	7,921	— 2.8	7,803	7,527	7,986	— 5.8
Domestic Crude Runs	6,776	6,859	— 1.2	6,783	6,598	7,001	— 5.8
Foreign Crude Runs	927	1,062	—12.7	1,020	929	986	— 5.8

	TOTAL U.S. STOCKS Millions of Barrels End of Month				STOCKS EAST OF CALIFORNIA Millions of Barrels End of Month			
	September			August	September			August
	1958	1957	% Diff.	1958	1958	1957	% Diff.	1958
Crude Oil	249.3	280.5	—11.1	247.1	209.6	242.8	—13.7	205.5
Gasoline	172.6	180.7	— 4.5	173.8	150.0	154.5	— 2.9	150.5
Distillate Fuel Oil	156.1	173.3	— 9.9	139.6	142.0	155.4	— 8.6	125.4
Residual Fuel Oil	68.9	58.7	+17.4	67.5	34.3	35.6	— 3.7	34.1
Kerosine	31.3	36.4	—14.0	28.7	30.9	36.0	—14.2	28.4

Source: Except for latest two months, all data from U.S. Bureau of Mines. Data forl ast two months from American Petroleum Institute weekly reports and U.S. Bureau of Mines weekly crude stock report: except U.S. Natural Gas Liquids Production and Demand figures which are from Chase Manhattan Bank Monthly report.

U. S. Crude Production By States

(THOUSANDS OF BARRELS)

	DAILY AVERAGE PRODUCTION				TOTAL PRODUCTION		
	September			August	January-September		
STATE or DISTRICT	1958	1957	% Diff.	1958	1958	1957	% Diff.
Alabama	15.3	15.4	— 0.7	17.0	4,418	3,948	+ 11.9
Arkansas	73.8	84.0	— 12.2	74.2	21,303	22,943	— 7.2
California	853.9	934.1	— 8.6	858.5	236,316	254,283	— 7.1
Colorado	130.4	148.2	— 12.0	131.0	36,555	41,700	— 12.3
Florida	1.3	1.3	.....	1.2	339	344	— 1.5
Illinois	228.3	227.5	+ 0.4	223.4	61,332	56,616	+ 8.3
Indiana	32.7	35.4	— 7.6	31.8	8,824	9,674	— 8.8
Kansas	333.7	323.1	+ 3.3	332.8	87,532	90,304	— 3.1
Kentucky	41.2	46.2	— 10.8	41.4	11,814	12,682	— 6.9
Louisiana	881.2	792.1	+ 11.2	848.9	227,359	248,620	— 8.6
North Louisiana	109.8	111.4	— 1.4	106.6	31,015	35,501	— 12.6
South Louisiana	771.4	680.7	+ 13.3	742.3	196,344	213,119	— 7.9
Michigan	24.4	27.9	— 12.6	25.2	6,909	7,707	— 10.4
Mississippi	107.0	98.4	+ 8.7	101.1	27,333	29,506	— 7.4
Missouri-Tennessee-South Dakota	.3	.3	.....	0.4	97	73	+ 32.9
Montana	77.6	77.3	+ 0.4	77.0	21,046	20,172	+ 4.3
Nebraska	57.4	58.0	— 1.0	58.6	14,949	14,194	+ 5.3
Nevada	.....	.....	.....	0.1	24	19	+ 26.3
New Mexico	279.6	246.1	+ 13.6	277.6	72,911	70,584	+ 3.3
Southeast New Mexico	252.2	239.4	+ 5.3	249.9	67,391	68,897	— 2.2
Northwest New Mexico	27.4	6.7	+308.9	27.7	5,520	1,687	+227.2
New York	5.1	7.3	— 30.1	5.1	1,535	2,027	— 24.3
North Dakota	17.1	27.4	— 37.6	34.4	10,269	10,477	— 2.0
Ohio	16.8	4.2	+300.0	16.0	4,688	3,585	+ 30.8
Oklahoma	560.0	557.6	+ 0.4	564.2	151,010	162,207	— 6.9
Pennsylvania	18.1	21.7	— 16.6	17.2	5,110	6,244	— 18.2
Texas	2,867.3	2,836.3	+ 1.1	2,703.5	684,733	834,812	— 18.0
Dist. 1: South Central	48.4	49.9	— 3.0	45.7	12,541	14,890	— 15.8
Dist. 2: Middle Gulf	134.8	133.0	+ 1.4	124.9	30,802	41,194	— 25.2
Dist. 3: Upper Gulf	401.7	417.7	— 3.8	378.3	101,571	123,455	— 17.7
Dist. 4: Lower Gulf	219.1	212.4	+ 3.2	201.4	50,817	63,806	— 20.4
Dist. 5: East Central	34.1	35.5	— 4.0	32.5	8,110	10,831	— 25.1
Dist. 6: Northeast	299.0	294.5	+ 1.5	277.8	68,851	91,591	— 24.8
Dist. 7-B: North Central	153.8	152.3	+ 1.0	142.9	36,996	44,130	— 16.2
Dist. 7-C: West Central	148.1	145.3	+ 1.9	136.2	35,585	44,638	— 20.3
Dist. 8: West	1,107.6	1,011.0	+ 9.6	1,051.7	250,993	308,299	— 18.6
Dist. 9: North	212.9	204.6	+ 4.1	206.0	53,731	57,459	— 6.5
Dist. 10: Panhandle	107.8	107.0	+ 0.7	106.0	29,075	28,747	+ 1.1
Utah	101.9	11.9	+756.3	100.0	16,027	2,786	+475.3
Virginia	.....	.....	.....	.....	3	4	— 25.0
Washington	.....	.....	.....	.....	7	.....	.....
West Virginia	6.4	6.1	+ 4.9	6.1	1,655	1,646	+ 0.5
Wyoming	325.0	299.0	+ 8.7	326.6	84,376	79,201	+ 6.5

Source: Bureau of Mines and API. Texas districts from API and do not necessarily agree with state totals.

gasoline supplies in the Midwest have been behind lower prices for this product.

Ironically, the latest reductions in gasoline prices have occurred despite considerable correction in gasoline stocks. In contrast with a 7-million barrel buildup during the corresponding period of 1957, gasoline stocks remained unchanged at 173.0 million barrels during the four weeks ended October 10.

Consequently, gasoline stocks now are 5 million barrels less than a year ago, whereas a month ago they had been 1 million barrels greater than a year before. This improvement has taken place outside of the West Coast. Gasoline inventories outside of the West Coast on October 10 were 1.7 million barrels below year ago levels, and only a month ago they had been 1.6 million barrels greater than the year before.

Even more ironical is the reduction in crude prices in the face of very low inventories of crude oil. Total U. S. crude oil stocks rose 11.6 million barrels during the latest four weeks, but still are quite low. On October 11 they totaled 252.3 million barrels, far below inventory levels during most of the past seven years.

The price picture boils down to the fact that refiners cannot pay the same prices for crude oil in the face of higher operating costs, when they receive lower prices on the gasoline they sell. Therefore, the recent reductions in Midwest gasoline prices darken the outlook sufficiently to overshadow low crude stocks and improvements in gasoline stocks.

Rising demand promises better statistical conditions for the industry in coming months. September demand was surprisingly strong, being 4.4 percent above the same month in 1957. However, 1957 demand was below normal.

October usually sees demand start climbing toward an annual high in January or February, which is 2 million barrels or more per day greater than in September. Since the expansion of imports is limited by quotas, domestic production will have to be increased sharply in coming months to satisfy likely winter season demand.

In view of some of the peculiar market actions in recent months, the industry must wait to see if higher winter demand will stop the downward trend of prices.

looking for oil
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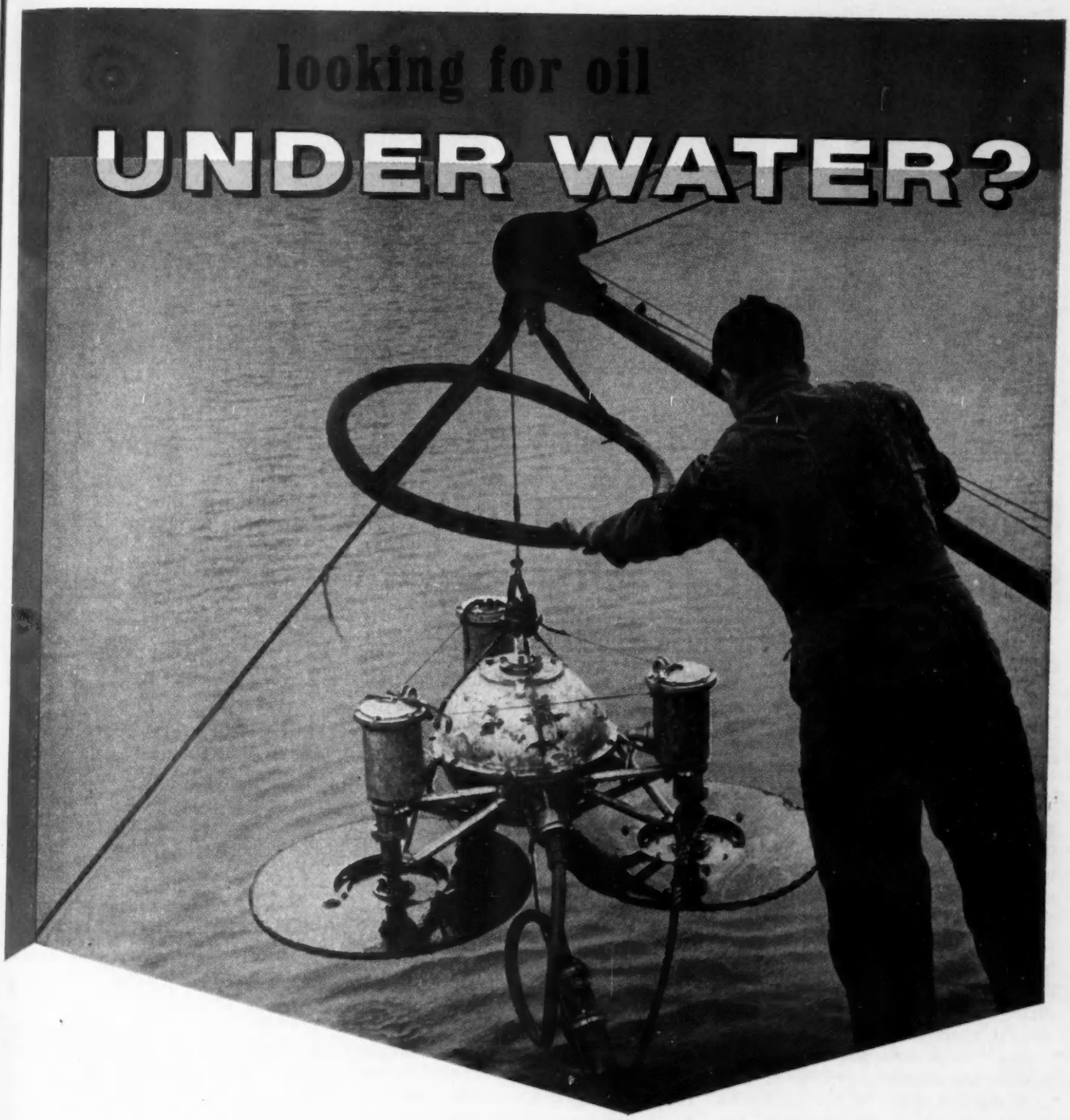

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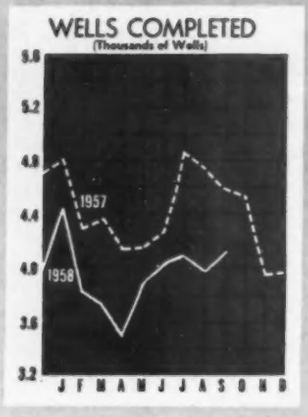
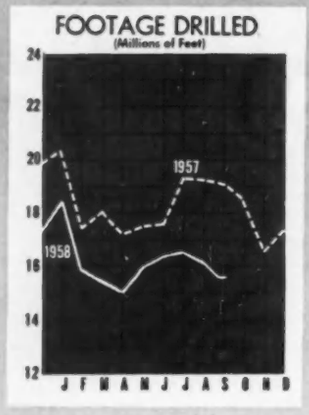
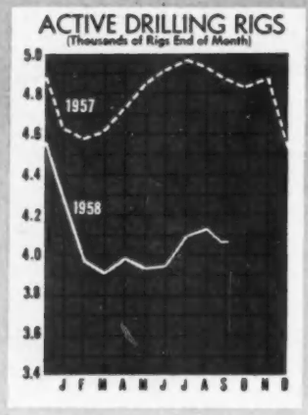
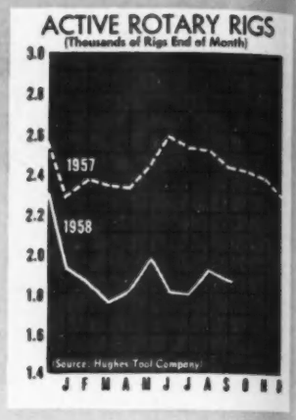
Drilling Activities...









New well completions in first 9 months of '58 reach 35,647

THROUGH THE first nine months of 1958, new well completions totaled 35,647 which indicates that WORLD OIL's forecast of 47,952 completions in the U. S. for this year will be reached.

New well completions in September again exceeded the 4,000-well pace. During each of the three previous months, completions amounted to more than 4,000 wells. No significant decline in drilling activity is anticipated in October. There is, in fact, a likelihood that the activity may quicken during the last quarter of the year as oil companies seek to complete their drilling programs within the calendar year.

New completions reported in September amounted to 4,134, or 118 wells more than the 4,016 completions (revised) in August and slightly below the 4,143 completions accounted for in July. These figures compare favorably with the year's low of 3,553 which was reported for April.

Continued drilling activity at the current rate would mean the completion of approximately 12,300 wells during the last quarter of this year. A total of 40,297 wells was completed during the first nine months of 1958. Consequently, the outlook is good for the completion of 47,952 wells in the U. S. this year.

Although a slight decrease was noted in the number of rigs in operation on September 30 as compared with August 31, indications were that completions during October again will hover at the 4,000-well level. On October 30, it was calculated that 4,083 rigs were in operation in the U. S. as compared with 4,127 rigs on August 31 (revised), 4,098 rigs at the end of July, 4,076 at the close of June, and 3,938 at the end of May.

However, it is expected that the two 31-day months in the last quarter will sustain the current 4,000-well completion level.

Although 118 more well completions were recorded in September as compared with August, footage drilled decreased 516,043 feet. During August, footage drilled totaled 16,121,973 feet, or 429,613 feet less than in July, the year's record footage month since January. However, the drop in August resulted from 149 fewer well completions than reported for July.

The well completion and footage rates for 1958, meanwhile, remain far below the 1957 figures, despite an increase in activity during recent months.

U. S. well completions in September, 1957, reached 4,606, or 239 less than the record for that year which was established in July. A total of 4,845 completions was reported for that month. That increased tempo in activity declined, however, and new well completions dropped steadily in succeeding months to reach a low of less than 4,200 completions during the final two months of the year.

Completion of 35,647 wells during the first nine months of 1958 is 11.5 percent below the 40,297 wells completed during the same period of the previous year. During the first nine months of this year, footage has totaled 145.2 million feet, or 12.7 percent less than the 166.3 million feet drilled during the similar period of 1957.

More wells were completed in Texas during September than in the preceding month. A total of 1,482 new wells was completed in the state in September as compared with 1,360 new wells in the previous month.

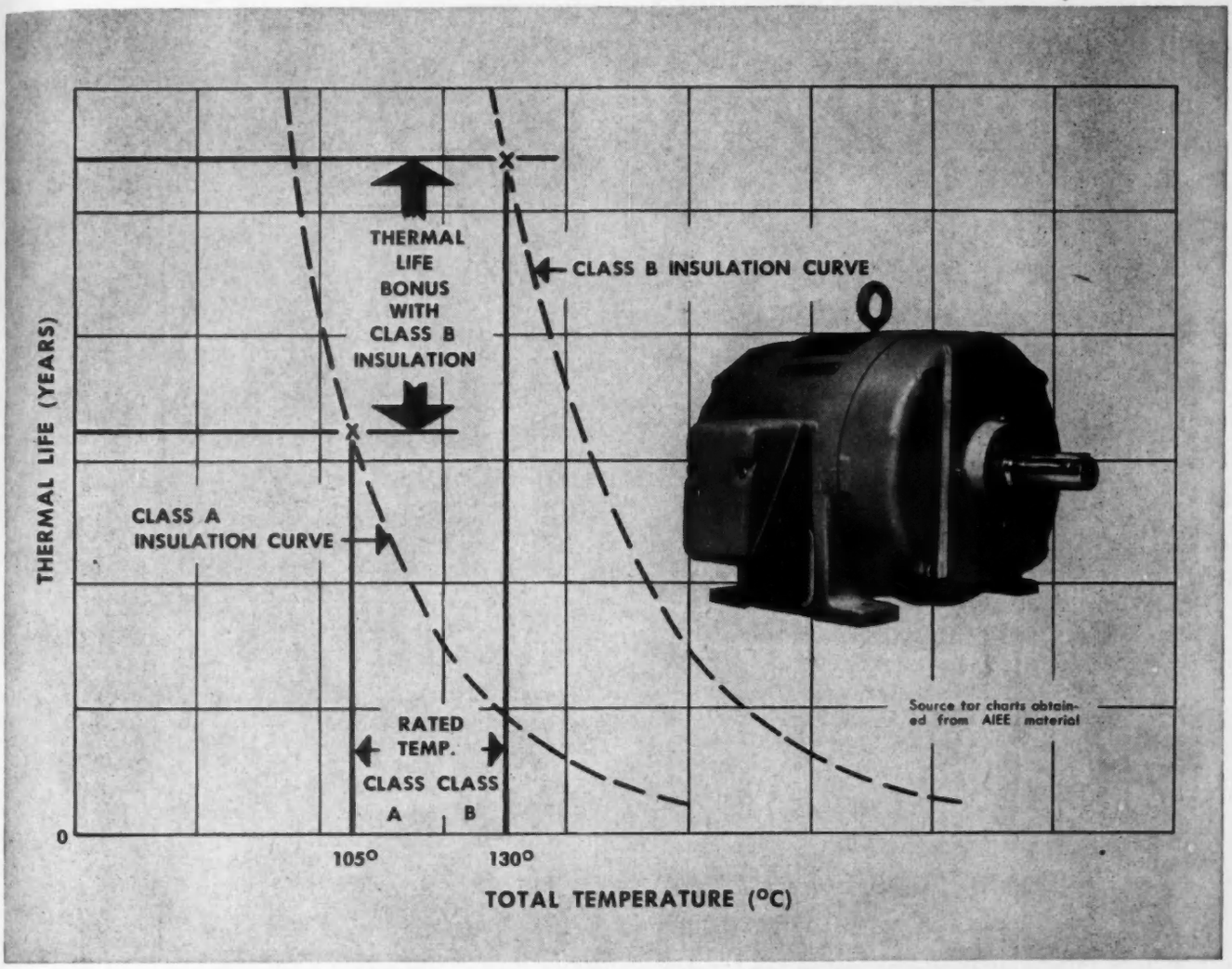
Summary of U. S. Drilling Activity

ITEM	Sep. 1958	Aug. 1958	NINE MONTHS January-September 1958	1957	% Dif.
New Wells Completed:					
Oil	1,986	1,891	17,595	21,053	— 16.4
Distillate	50	97	585	539	+ 8.5
Gas	346	352	3,118	2,781	+ 12.1
Service	133	93	1,009	792	+ 27.4
Dry	1,619	1,583	13,340	15,132	— 11.9
Total Wells	4,134	4,016	35,647	40,297	— 11.5
Footage Drilled (Mln. of Feet)	15.6	16.1	145.2	166.3	— 12.7

Summary of U. S. Wildcat Drilling

ITEM	Sep. 1958	Aug. 1958	NINE MONTHS January-September 1958	1957	% Dif.
New Field Discoveries:					
Oil	50	56	538	642	— 16.2
Distillate	5	8	69	92	— 25.0
Gas	18	18	169	172	— 1.8
Total Discoveries	73	82	776	906	— 14.4
Dry Wildcats	813	740	6,438	7,664	— 16.0
Total Wildcats	886	822	7,214	8,570	— 15.8
Percent Productive	8.2	10.0	10.8	10.6	.....
Percent Dry	91.8	90.0	89.2	89.4	.....

Details on Page 30



LIFE-EXPECTANCY CHART shows relative life spans of insulations. With motors operating at rated temperatures, Class B insulation gives 70% longer winding life than Class A-insulated windings.

GENERAL ELECTRIC OIL FIELD MOTORS, WITH ALKENEX* CLASS B INSULATION, OFFER . . .

70% Longer Winding Life

Recent laboratory tests—confirmed by actual field experience—have demonstrated that General Electric Oil Field Motors—with Alkenex Class B insulation—give far greater winding protection than motors having Class A insulation.

As indicated by the life-expectancy chart, windings of Class B-insulated motors will last up to 70% longer than Class A-insulated windings if both motors are operated at rated temperatures. And, since G-E oil field motors are designed to operate within actual nameplate ratings, this extra service life can be fully realized.

Even in the case of inadvertent overloading, the Alkenex Class B-insulated motors will stay on the line longer at temperatures that would burn out Class A insulations.

LONGER BEARING LIFE—To achieve longer bearing and grease life, the Tri-Clad* '55' motor provides an extra-large grease reservoir and a specially-engineered double-end ventilation system.

The grease reservoir actually holds up to five times more grease than is possible in sealed-bearing systems. And the ventilation system pulls cool air in over *both* bearing housings, so that bearing and grease temperatures are only a fraction of motor temperatures.

By utilizing these insulation, bearing, and cooling systems, G-E engineers have achieved major reductions in motor size, while actually improving performance and dependability.

PROOF IN APPLICATION—Since the General Electric Alkenex Oil Field Motor was introduced in 1956, thousands have been installed in oil fields throughout the U.S. and Canada. During this period, the performance record of these motors has been outstanding. Even the 1957 Texas floods put only a small number out of service.

This remarkable record can pay important dividends in *your* oil field pumping operation. Longer motor life, with fewer breakdowns can mean larger profits from wells. For more information on the reliable G-E Alkenex Oil Field Motor, contact your nearby General Electric distributor or Apparatus Sales Office. General Electric Co., Schenectady, New York.

*Reg. trademark, General Electric Co. 899-2

GENERAL ELECTRIC

For more data on advertised products, use Readers' Service Cards, last page.

U. S. Drilling Activity In September and First Nine Months, 1958-1957

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED: DETAILS FOR SEPTEMBER, 1958 Oil	Dist.	Gas	Dry	Service Wells	TOTAL NEW WELLS Sept. 1958	Aug. 1958	Sept. 1957	Total Footage September, 1958	DETAILS FOR JANUARY-SEPTEMBER NEW WELLS 1958	1957	Percent Diff.	FOOTAGE 1958	1957	WILDCAT DRILLING IN SEPTEMBER AND FIRST NINE MONTHS, 1958-1957: DETAILS FOR SEPTEMBER, 1958 Oil	Dist.	Gas	Dry	Total Wildcats	DETAILS FOR JANUARY-SEPTEMBER Oil	Dist.	Gas	Dry	TOTAL WILDCATS 1958	1957	DRILLING RIGS IN OPERATION (Rigging up, Drilling, Temp. Shut-Down) Sept. 30, 1958	Aug. 31, 1958	Sept. 30, 1957
Alabama	6	....	....	4	....	10	6	4	74,946	61	75	— 18.7	506,068	660,698	....	....	....	4	4	....	....	....	23	23	27	16	13	9
Arkansas	46	1	6	30	....	83	101	94	274,361	579	833	— 30.5	1,932,657	2,499,764	....	....	1	1	11	13	6	2	7	101	116	132	46	49	64
California	52	....	1	41	....	94	99	199	426,977	1,041	1,646	— 36.8	4,975,943	7,105,715	....	....	....	....	31	31	6	....	2	187	195	274	128	134	184
Colorado	8	....	4	55	....	67	77	73	332,213	622	606	+ 2.6	3,214,761	3,139,173	....	....	....	....	44	44	20	....	11	313	344	365	65	65	66
Florida	....	....	....	1	....	1	1	....	7,005	6	8	— 25.0	55,809	57,082	....	....	....	....	1	1	....	....	....	6	6	8	2	2	....
Georgia	....	....	....	1	....	1	....	....	2,915	1	3	— 66.7	2,915	18,955	....	....	....	....	1	1	....	....	....	1	1	3	1	1	....
Illinois	168	....	1	137	2	248	217	252	566,748	1,698	1,957	— 13.2	3,882,207	4,495,053	....	....	....	....	68	68	5	....	....	445	450	562	305	301	233
Indiana	23	....	....	71	....	94	73	55	148,597	586	493	+ 18.9	955,337	807,397	....	....	....	....	36	36	3	....	1	165	169	131	105	109	101
Kansas	167	....	25	167	14	373	320	354	1,278,389	2,697	3,122	— 13.6	9,276,301	11,084,052	13	....	2	79	94	91	....	20	596	707	756	299	335	599
Kentucky	40	....	20	71	1	132	142	182	203,977	1,046	1,293	— 19.1	1,519,649	1,902,262	1	....	....	9	10	7	....	2	49	58	94	119	118	147
Louisiana	109	18	24	126	1	278	331	386	1,825,212	2,566	2,814	— 8.8	20,194,225	22,340,152	3	2	1	45	51	27	16	6	380	429	454	383	360	444
North Louisiana	57	1	20	66	....	144	145	155	526,855	954	1,053	— 8.5	3,635,868	3,841,291	3	....	....	19	22	12	....	....	126	138	132	113	93	86
South Louisiana	52	17	4	60	1	134	186	231	1,298,357	1,632	1,761	— 9.0	16,558,357	18,498,861	....	2	1	26	29	15	16	6	254	291	322	270	267	358
*Gulf of Mexico	18	....	1	10	....	29	55	57	281,886	384	494	— 22.3	3,686,808	4,665,903	....	....	1	2	3	3	1	2	28	34	55	45	35	81
Michigan	10	....	2	12	....	24	28	39	62,291	273	300	— 9.0	788,429	864,186	....	....	1	6	7	5	....	3	84	92	103	76	78	79
Mississippi	10	....	2	18	....	30	35	41	261,231	277	291	— 4.8	2,474,747	2,100,420	1	....	....	13	14	10	1	....	104	115	152	57	50	53
Missouri	....	....	....	2	....	2	1	5	1,710	13	9	+ 44.4	11,582	6,110	....	....	....	2	2	....	....	....	6	6	9	4	2	....
Montana	13	....	....	7	....	20	24	36	106,148	223	299	— 25.4	1,193,041	1,503,733	....	....	....	4	4	5	1	4	78	88	104	35	40	62
Nebraska	24	....	....	43	....	67	51	85	410,913	487	682	— 28.6	2,906,250	4,033,736	1	....	....	28	29	20	....	....	203	223	352	35	44	34
Nevada	....	....	....	....	....	....	....	....	....	....	4	—100.0	....	10,568	....	....	....	....	....	....	....	....	....	....	4	1	1	1
New Mexico	64	....	41	35	....	140	210	207	650,603	1,485	1,673	— 11.2	7,003,724	7,833,224	3	....	....	21	24	28	2	15	166	211	225	175	169	174
Southeast	46	....	....	24	....	70	105	119	338,583	758	1,018	— 25.6	3,763,930	5,071,756	3	....	....	17	20	20	2	4	107	133	146	62	61	101
Northwest	18	....	41	11	....	70	105	88	312,020	727	655	+ 11.0	3,239,794	2,761,468	....	....	....	4	4	8	....	11	59	78	79	113	108	73
New York	24	....	1	2	18	45	45	48	53,400	405	375	+ 8.0	189,600	603,800	....	....	....	....	....	....	....	....	....	....	....	....	42	42	60
North Dakota	14	....	....	13	....	27	40	26	153,647	313	197	+ 58.9	2,044,781	1,376,421	1	....	....	8	9	19	....	....	79	98	89	40	31	45
Ohio	32	....	18	18	....	68	92	109	175,365	728	763	— 4.6	1,877,702	1,838,568	....	....	....	....	....	....	....	....	7	7	8	224	227	195
Oklahoma	338	3	27	203	55	626	529	364	1,855,534	5,372	4,244	+ 26.6	16,706,705	15,379,691	6	1	2	58	67	49	11	26	482	568	494	473	445	603
Pennsylvania	18	....	22	6	8	54	59	93	149,461	509	728	— 30.1	1,483,312	1,902,970	....	....	....	....	....	....	....	....	....	....	35	162	175	185
South Dakota	....	....	....	....	....	....	2	4	....	5	34	— 85.0	22,187	122,344	....	....	....	....	....	....	....	....	5	5	32	3	4	2
Tennessee	....	....	1	4	....	5	5	....	6,000	45	....	....	56,200	....	....	....	....	2	2	....	....	....	18	18	....	....	....	....
Texas	820	28	108	493	33	1,482	1,360	1,794	5,943,387	13,124	16,599	— 20.9	55,519,231	69,725,728	21	1	11	312	345	229	36	68	2,708	3,041	3,864	978	980	1,184
Dist. 1: South Central	68	3	2	31	....	104	61	124	238,059	745	1,008	— 26.1	1,800,931	2,581,884	1	....	....	22	23	10	1	1	247	259	289	39	34	32
Dist. 2: Middle Gulf	12	7	9	28	....	56	62	64	377,063	536	589	— 9.0	3,277,857	3,629,471	2	1	1	24	28	10	8	9	156	183	200	34	34	32
Dist. 3: Upper Gulf	37	7	5	35	....	84	106	139	522,913	951	1,292	— 26.4	6,063,647	8,559,291	2	....	1	18	21	8	3	7	241	259	346	82	67	101
*Gulf of Mexico	....	....	....	....	....	....	1	....	....	9	7	+ 28.6	72,271	52,372	....	....	....	....	....	1	....	1	5	7	3	1	....	2
Dist. 4: Lower Gulf-S.W.	25	9	11	45	....	90	96	119	471,632	904	1,103	— 18.1	4,655,777	5,811,208	2	....	1	33	36	18	11	3	325	360	341	53	54	71
*Gulf of Mexico	....	....	....	....	....	....	....	3	....	7	19	— 10.5	75,300	181,268	....	....	....	....	....	....	....	....	2	2	2	....	....	2
Dist. 5: East Central	8	....	1	16	....	25	12	21	88,329	151	129	+ 17.1	561,546	584,652	....	....	....	15	15	2	1	1	86	90	88	16	14	10
Dist. 6: Northeast	45	....	3	22	....	70	63	95	353,220	628	829	— 24.3	3,296,992	4,478,267	....	....	....	12	12	5	3	3	147	158	192	62	65	71
Dist. 7-B: North Central	81	1	13	91	2	188	183	227	598,044	1,626	2,054	— 20.8	5,229,651	6,902,634	2	....	1	66	69	57	3	8	507	575	762	76	79	98
Dist. 7-C: West Central	36	....	4	14	....	54	57	103	276,920	588	903	— 34.9	2,926,445	4,082,578	2	....	2	13	17	24	....	6	142	172	259	65	71	79
Dist. 8: West	283	....	5	63	15	366	318	395	1,651,851	3,183	3,794	— 16.1	15,242,083	18,615,225	6	....	2	44	52	55	1	6	332	394	406	275	293	360
Dist. 9: North	165	....	10	123	16	314	299	396	837,691	2,820	3,787	— 25.5	8,113,464	10,050,968	3	....	1	55	59	30	2	6	454	492	872	181	169	210
Dist. 10: Panhandle	60	1	45	25	....	131	103	119	527,665	992	1,111	— 10.7	4,380,838	4,429,950	1	....	2	10	13	10	3	15	74	102	109	94	103	120
Utah	13	....	2	6	....	21	22	46	127,973	315	178	+ 76.9	1,756,016	980,798	....	....	....	6	6	....	....	....	64	64	79	33	35	79
Washington	....	....	....	1	....	1	....	....	5,069	5	4	+ 25.0	25,863	20,459	....	....	....	1	1	....	....	....	4	4	3	1	....	1
West Virginia	17	....	30	16	....	63	71	64	169,484	620	483	+ 28.4	1,665,024	1,317,028	....	....	....	1	1	....	....	....	6	6	16	189	195	175
Wyoming	30	....	6	34	1	71	72	45	301,074	522	579	— 9.9	2,506,779	2,542,054	....	....	....	21	21	8	....	3	142	153	190	80	114	103
Others	....	....	5	2	....	7	3	....	31,300	23	5	+ 40.0	104,931	18,844	....	....	....	1	1	....	....	1	16	17	5	6	8	5
Total United States	1,986	50	346	1,619	133	4,134	4,016	4,606	15,605,930	35,647	40,297	— 11.5	145,172,976	166,290,985	50	5	18	813	886	538	69	169	6,438	7,214	8,570	4,083	4,127	4,887
Total Western Canada	138	....	13	61	12	224	221	246	1,098,404	1,751	2,993	— 41.5	9,036,915	13,968,509	....	....	....	....	....	....	....	....	....	....	....	237	238	201

* Gulf of Mexico wells are included in their respective district total.

For more data on advertised products, use Readers' Service Cards, last page.

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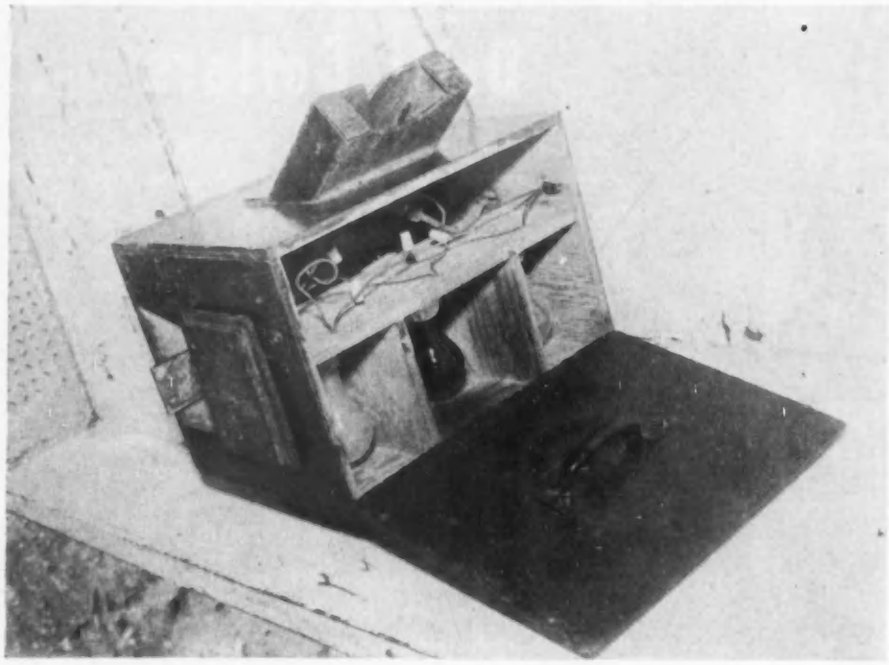
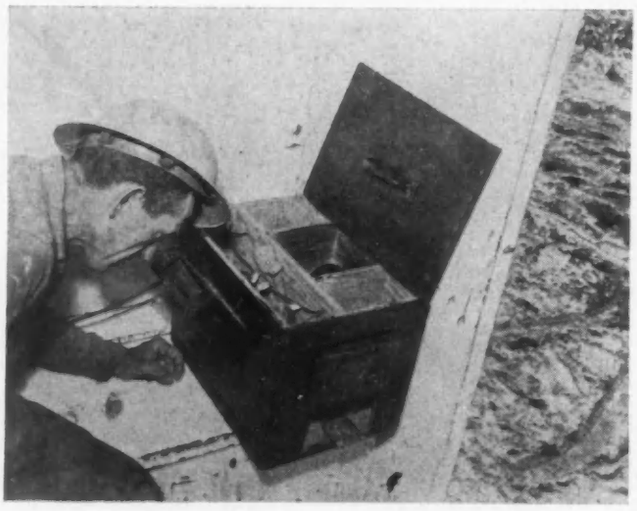


Box Shows Samples by Ultraviolet Light

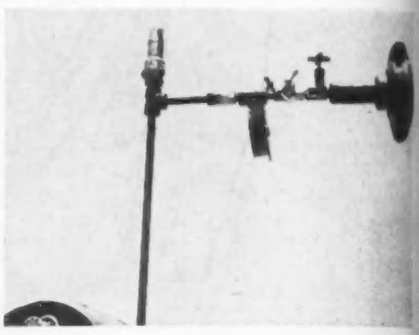
A simple box may be made for viewing samples under ultraviolet light by using an ultraviolet light bulb mounted in a box with other light bulbs. All the bulbs are connected to one switch, but each one is boxed off so that the sample can be put directly under the ultraviolet bulb or slid to one side for normal light viewing.



The box is approximately 18 inches long by 14 inches wide and deep. The compartments for the bulbs are approximately 6 inches long by 4 inches wide. Space is provided at the base of the bulbs for the wiring. A door near the bottom provides space for inserting the samples of cuttings. On the front of the box, an "eye-piece" allows the geologist to peer into the box without interference from the daylight outside.

High Pressure Pop Valve Keeps Line From Bursting

Installation of a relief valve on a high pressure chemical injection line can save a string of tubing or casing from bursting due to excess pressures.



The line shown is operating at a pressure of 7,500 psi. Corrosion inhibitor is being pumped into the annular space between two strings of tubing. The inhibitor normally falls to the bottom of the annulus, mixes with the well stream and flows out of the well through the inside tubing string.

If the annulus between the tubing strings should become plugged, pipe in the strings concerned will be subjected to tremendous pressure (up to 20,000 psi). If the relief valve is installed as shown, the pressure will not reach a dangerous point. The relief valve is set to "pop" at a pressure of 8,000 psi. This will be the maximum pump pressure to which the tubular goods will be subjected.

The check valve shown downstream of the "pop" prevents back-flow from the well.

How-To-Do-It Ideas Earn Money, too!

WORLD OIL editors want how-to-do-it ideas, so your favorite short cut or invention could put money in your pocket! Write down the substance of your latest ideas and send them in with a picture or drawing of the installation . . . if accepted, $10 for each idea will be yours. Send those money-making ideas today to Hints Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

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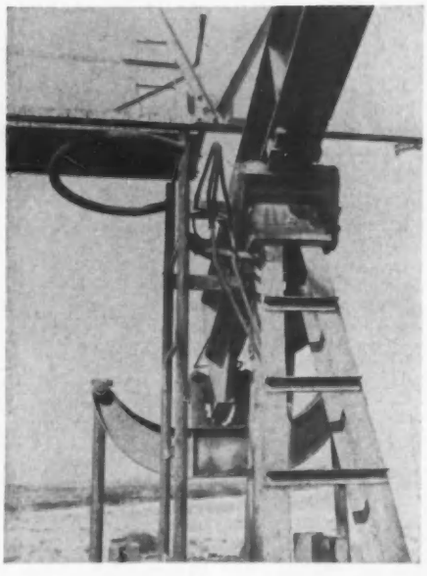
Trailer-Mounted Doghouse Travels With Operator

One Gulf Coast workover operator has as his doghouse a semi-trailer which he moves on location and parks in a convenient location. He has built into the trailer such items as part bins, crew lockers, the knowledge box etc. For short term jobs, this type of set-up is very convenient.

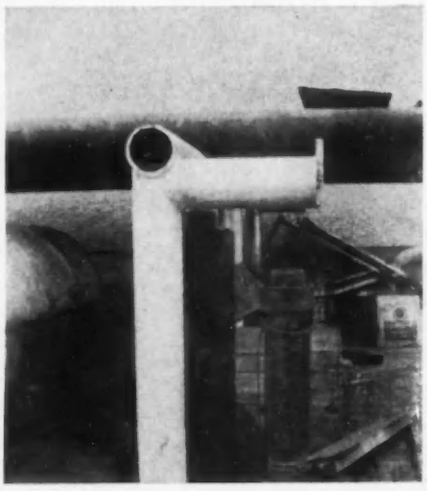


Panel Simplifies Installing Of Lube Extension Line

An improved method of mounting intermediate terminals for extension of lubrication lines so center and tail bearings can be worked with from ground level is seen in this pumping unit installation.

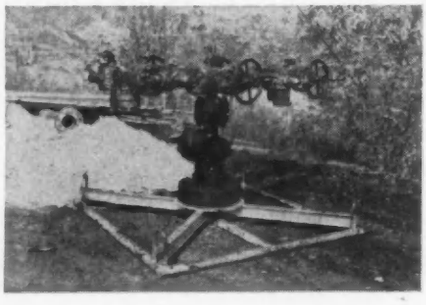
By welding a flat steel plate to the web and at right angles to the beam immediately above the center bearing, an intermediate panel is provided to which both the moving and fixed segments of the lines may be attached. The fixed copper tubing or ¼-inch pipe lines extend to the bearing points from the back side of the panel; the flexible hoses, which absorb the beam motion, are mounted on the front side.

Since motion of the beam is at a minimum at the center bearing, this type of installation insures a longer life for the hose sections by keeping motion to a minimum; also holding it to travel in only one plane.



Extension on Pipe Rack Makes Loading Easier

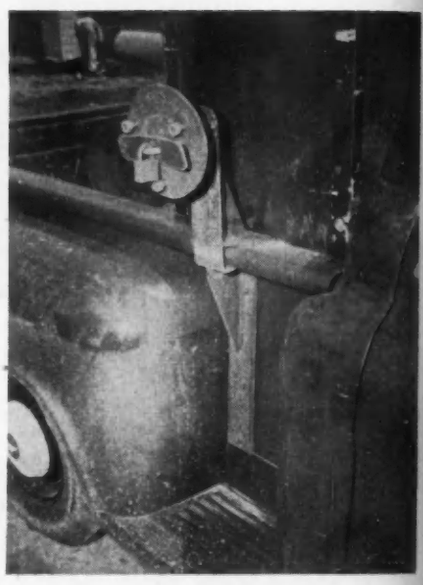
Loading on the pipe racks can be easier through the use of an extension made of 4-inch pipe as shown in the accompanying photograph. This extension is approximately the width of a 12-inch plank. This plank can be placed on this pipe bracket and extended to the truck bed. The pipe can then be rolled onto the rack with considerably less effort than present procedures.



Flat Pipe Rack Prevents Damage to Christmas Tree

The possibility of damage occurring to the christmas tree whenever tubing is pulled and the well worked on, is materially reduced by the specially-designed, though inexpensive device used by one major company. It consists of a simple flat pipe rack to which is welded a cross of I-beams. The tree is placed on a ¾-inch steel disc welded to the center of the cross and secured with several bolts. Lifting eyes are welded to each corner of the unit as shown.

Mounted on such a base, the tree then can be lifted with an A-frame and deposited out of harm's way at the edge of the location until needed. The broad base assures stability, and little likelihood exists that it would be tipped over. The cost of the device easily can be repaid out of rig and crew time saved in cleaning up flanges, fittings or repairing of damaged high pressure fittings and valves.



Bent Flat Iron Provides Support for Spare Tire

Since lease cars do not usually have a convenient place to keep and lock the spare tire, they usually take up room on the truck bed or are left unlocked. A neat support for the tire and wheel may be made by taking pieces of 3-inch flat iron and bending them to the contour of the outside of the truck sideboard just ahead of the rear fender. Braces are then cut and fit to the inside of the bends to make a tight rig. Holes are then drilled through the flat iron and the side of the bed and bolts inserted to make a strong support.

The carrier for the tire is made by welding three lug bolts in a circular piece of flat iron and then welding the assembly to the top of the support. The lock is made by simply welding a hasp to the center of the circular piece and making a slotted piece to fit over it against the wheel and inserting a lock.

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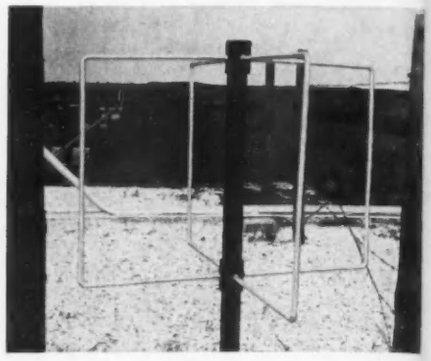


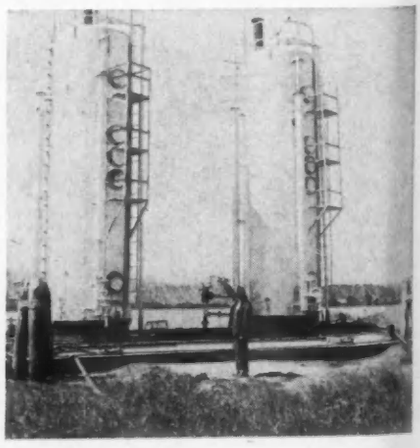
Scrap Tubing, Sucker Rods Become Lease Turnstile

The turnstile illustrated is easily constructed from junk material found around most leases.

A length of 2-inch tubing is driven vertically into the ground. Two E.U.E. tubing collars are then utilized as guides. The upper collar has a flat steel plate welded to the top end while the lower coupling is left with each end open.

Sucker rods or lengths of ½-inch pipe are used to form the "wing" portions of the turnstile. The rod or pipe is bent and welded into place as shown. The entire assembly is slipped over the vertical pipe previously driven into the ground. The turnstile is supported by the steel plate in the upper tubing coupling.

The device may be easily removed if bulky materials or equipment are to be moved into the fenced area.

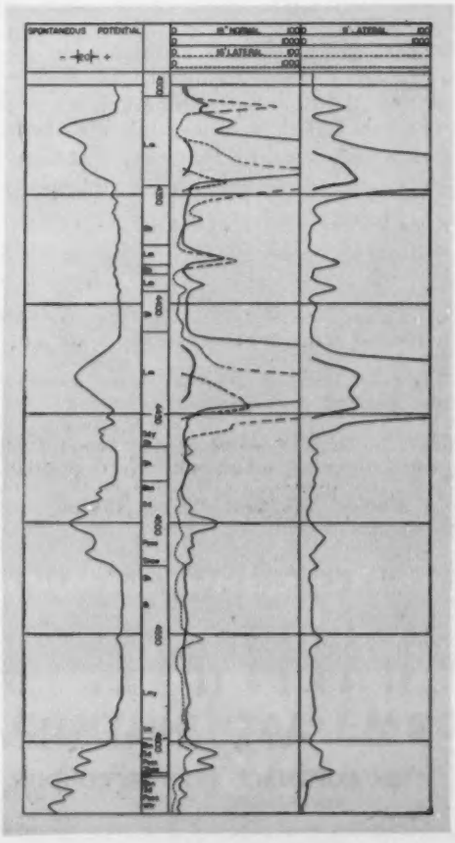


Platforms Make Cleanout Of Heater Treater Safer

Installing platforms below heater treater clean-out manways reduces considerably the time required to clean this type of vessel. The platforms are extremely useful in sand producing areas where clean-out jobs are frequent occurrences.

The installation is much safer for

PRODUCTION GUIDES



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personnel than by utilizing the usual method of clean-out which involves hoisting a man to the appropriate manhole in a boatswain's chair by use of block and tackle. This method was both awkward and dangerous.

The platform surface is constructed of skid-proof grating. Angle iron is used for frameworks and bracing. A ladder, installed as shown in the photograph, provides safe, convenient access to the platforms.

The entire assembly can be prefabricated on the ground prior to actual installation on the vessel. The assembly is hoisted into position and welded to the heater shell after the vessel has been properly conditioned and pronounced gas free.

Simple Pipe Connections Convert to Rig Desander

Crews of one drilling contractor utilized simple pipe connections that can be found around any rig to build a cyclone type desander for use on the rig's mud system. These simple desanders have worked efficiently in removing excess sand from mud that is pumped through the device.

As shown in the picture, the desanders were each built from two 4-inch swedges, coupled together with a collar and made up with a top return mud outlet line. Two-inch line pipe, returning clean mud to the pit, was made up into the two-inch ells that were fitted onto the top of the 4-inch swedges. The two bottom swedges were fitted with restricted collars that serve as positive chokes and filter out any sand which settles to the bottom of the desander. Mud pumped through the 2-inch input lines swirls around inside the swedges; sand settles out into the bottom while the clean return mud goes back into the system.

There's RESERVE CAPACITY in this LIGHTWEIGHT PUMP

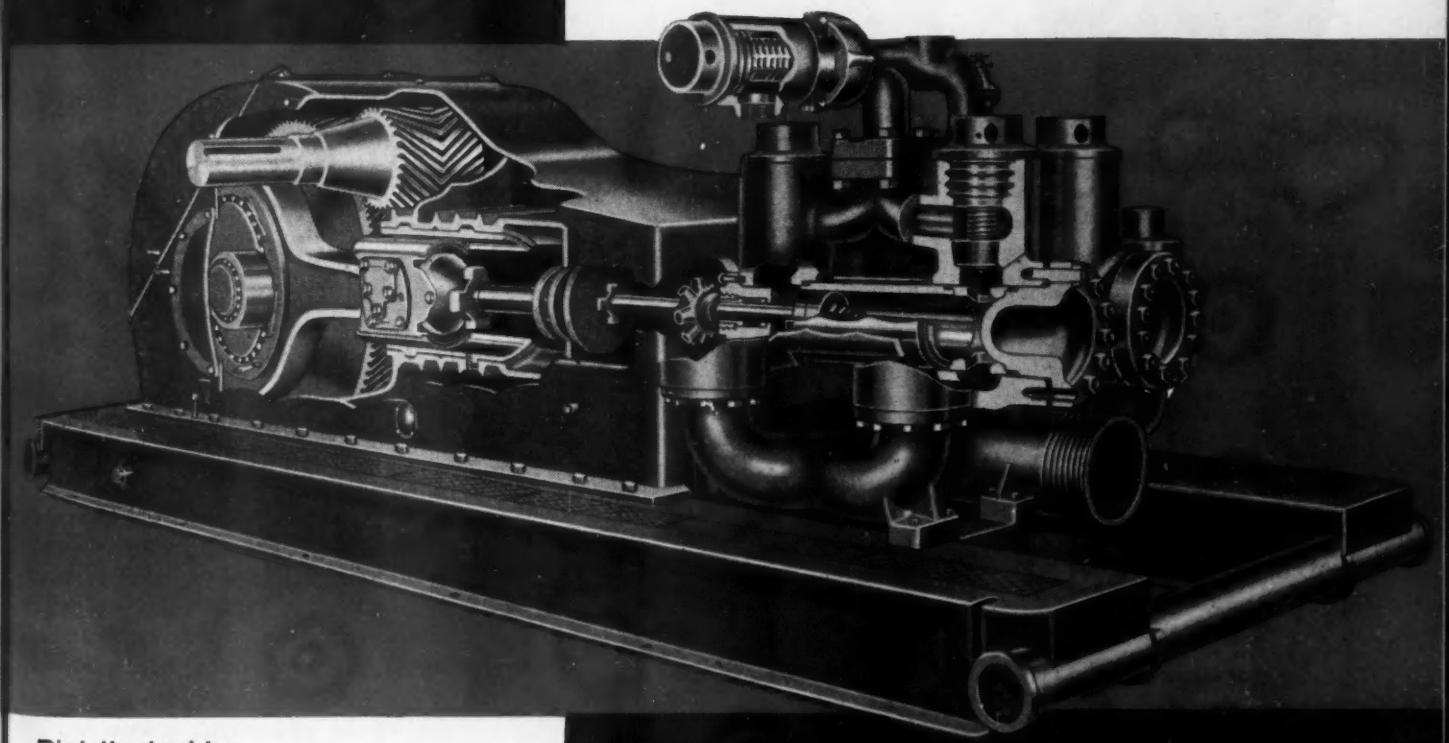
Examine this cross section of a Continental-Emsco Series D Slush Pump. Note how *extra power* has been built into the large main gear . . a wide-faced, forged-steel herringbone gear . . heat treated for years of heavy-duty pumping. The pinion and pinion shaft are integral . . made of high-alloy, forged steel . . fully heat treated.

Eccentrics are equipped with large diameter roller bearings, which results in an extremely narrow and compact power end. The eccentric straps are made of one-piece alloy steel.

You can see how the sides of the power-end housing are not thick, as are solid castings. Steel plates and shapes have been utilized instead of bulky castings to provide a light, rigid power-end. This is *Fabriform construction* . . the big *weight-saving* feature of Continental-Emsco Pumps for lower-cost transportation and easier rigging-up. You get *more horsepower per pound* than in any other slush pump.

Maintenance features are outstanding in the design of the D Series Slush Pumps. Patented "exposed" liner design *minimizes fluid-end washouts* caused by liner-packing failures, and no greasing is necessary, since lubrication is completely automatic.

One of these six Continental-Emsco Slush Pumps will meet your drilling requirements: D-175, D-300, DA-500, D-700, DA-850, D-1000. Ask your supply representative for all the data on these pumps.



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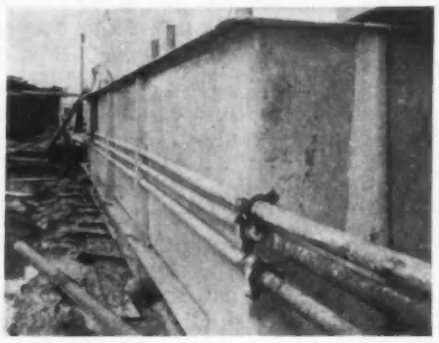
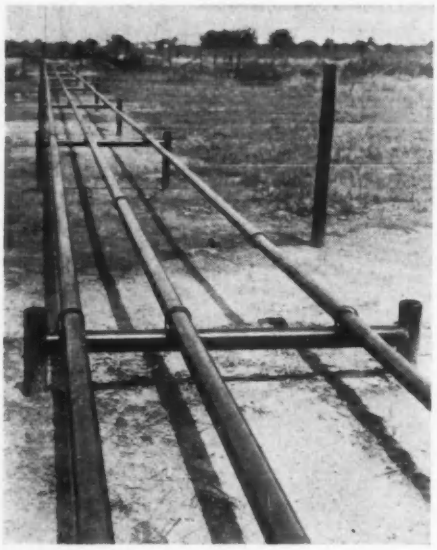


Quicken Rigging Up Time With Piping on Mud Tank

Where the auxiliary unit is put out away from the rig, a simple means of running the piping is fastening them up beside the mud tanks as shown. Then it is only necessary to hook the tanks together and connect into the piping on the derrick floor and the auxiliary unit.

The water line is on the top, the gas line in the middle and the air pressure line on the bottom. Short lengths of steel hose are used to make the connections in a few minutes, and it is not necessary to string lines around the rig which may be in the way of the workmen.

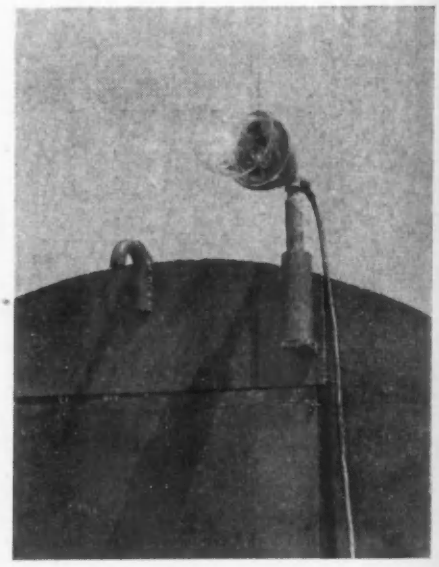


Save Junk Pipe for Use As Line Support Pier

A functional pipe line support pier can easily be constructed from junk pipe.

Tank battery pipe lines are especially adaptable to this type of support. Junk pipe, which can usually be found around any oil field, provides a cheap, readily available construction material. Since a welder is usually employed on tank battery projects, the cost of additional time required for constructing this type of pier is relatively negligible. The supports as shown require no concrete. Lines are guided on the supports by thin steel straps which also serve as holddowns.

All piers are pre-fabricated, driven into the ground and leveled. The required number of lines are laid and straightened. The holddown straps are then installed and tack welded to the support as indicated in the photograph. Since no concrete is required, form lumber, cement etc. are not required. Other elaborate methods required to attach lines to concrete foundations are also eliminated.



Light Standard Rests In Pipe Socket Pedestal

Utility, convenience and ease of handling at moving time are combined in this general illumination lamp used by one contractor. Instead of building a tripod or other type of light standard, a short piece of pipe was mounted on a pedestal near the highest point on one of the doghouses.

The light, equipped with a pipe fitting at the socket end, is attached to a short but heavy piece of steel stock. It requires but a minute, when rigging up, to uncoil the extension cord and drop the light assembly in the socket. Stringing of electric wires is eliminated, as is the necessity of spotting a light standard out in the yard area where turning and moving space is needed for trucks. This type of support also reduces costs involved in handling and trucking between locations.

ADDITIONAL DATA: Improved Cages

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Metallic back-stop is now available in Closed Type Cages by use of 18-8 insert in upper part of rubber guide. Ball never touches this metal in normal pumping.

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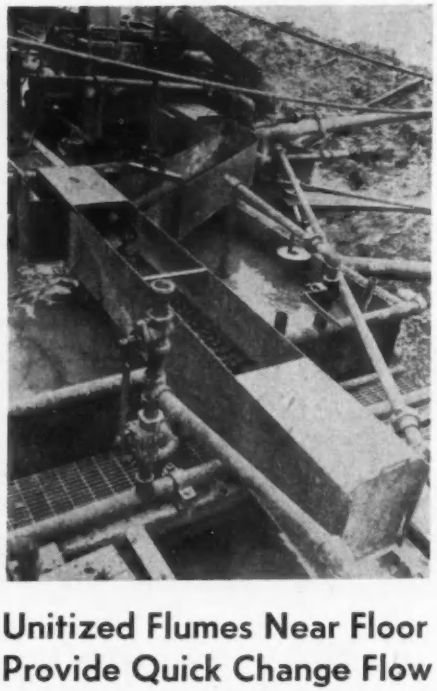
Drive Chain Lubricated Continuously With Unit

A method of continuously lubricating the drive chain for the slush pumps was devised by one Gulf Coast contractor. The unit was built into the chain guard itself. A triangular shaped reservoir was mounted on the top side of the chain guard. The lubricant flowed from the reservoir through a piece of small metal tubing and dripped onto the chain.



Unitized Flumes Near Floor Provide Quick Change Flow

By placing the mud tanks parallel to and near the rig floor, one drilling contractor makes it easy to change the mud stream from one tank to another with a minimum of steel mud ditches. When circulation is lost, it takes only a few seconds to switch to the proper tank which has the proper mixture of mud and at the same time save the expensive mud from the suction tank from being lost down the hole.

The flume is only slightly longer than the width of two tanks. Three tanks are set side by side and the flume is zig-zagged between them as shown with a side opening and a block gate above the first tank. The second tank is equipped with only a side opening and the last tank has only a gate on the end of the flume. Material to prevent lost circulation is kept in the end tank and when the suction tank in the middle begins to lose its level, the returns are bypassed over the other two tanks and emptied into the last tank.

Convert Scrap Pipe, Metal Into Shopmade Gager's Box

If you need a container for holding run tickets or messages for the pumper or gager on your lease, this homemade mailbox might do the job.

Cut a piece of 6-inch pipe about 1 foot to 18 inches long and weld a plate over one end to form the back. Make a similar plate for the front, but instead of welding it in place, pivot it at the top on a bolt as shown in the illustration. By welding a small piece of ¼-inch rod on the front cover plate for a handle, the container is complete. The weight of the pivoted plate is enough to keep the container closed and the contents safe from the weather.

The container can then be mounted on a length of 2-inch pipe and supported or reinforced by a piece of sucker rod. To prevent rain from running into the container, it should be mounted with the front end slightly lower than the back end. This type of message box can be made very attractive and adds to the appearance of a lease.

"Independent oil men are here to stay. Not all of them, maybe, but lots of them."

The U. S. oil industry is in the midst of another steady, but certain evolutionary change. Imports, shale oil, new sources of energy, well spacing and unitization are exerting powerful economic pressures on the independent oil man—and will more so in the future.

WILL INDEPENDENTS SURVIVE THE CHANGE?

You will find a straight-from-the-shoulder answer on these pages. Every independent oil operator and every major oil company official should read this evaluation of some of the most pressing problems confronting the U. S. oil industry today.

An independent's blueprint for survival

One of the nation's top oil operators gives his candid appraisal of the problems of the present—and what can be done about them in the future

By Michel T. Halbouty
Consulting Geologist and Petroleum Engineer
Independent Producer and Operator, Houston

THE STATUS of the independent in the present day oil industry can be summed up in one word—precarious—and more so, if he doesn't watch out.

But just to say that the independent oil operator is in serious jeopardy is not saying anything not already known. Independents, collectively and individually, have told everyone who would listen that their road is rocky and rough and seems to be leading to oblivion. I'm an independent and I've cried the blues myself. As a man not much given to keeping quiet, I've found many occasions to pound the table and exercise my lungs over situations and developments that seemed to be expressly designed to put me out of business. I've been angry—I've been frustrated—I've been hurt—and I've hollered!

In the heat of the moment I have joined those who predict the independent will shortly become as extinct as the dodo. Sometimes it looks that bad. But, on more sober reflection I have to tell you that it simply isn't so. Independent oil men are here to stay. Not *all* of them, maybe, but lots of them. As in nature, the principle of the survival of the fittest will prevail. The independent is going through an evolutionary process, and he'll be the better for it—those who survive!

This process of continual change is not new, of course. It is going on gradually every day and by more precipitous spurts every time there is upheaval in the industry. It happened after Spindletop, after East Texas, and during the depression. Outmoded practices fell by the wayside. Weak companies and individuals disappeared. The strong and the adaptable carried on.

So in these pages I want to share some ideas with you, some ideas about the *kind* of independent who will survive and some of the things we independents can and ought to do to insure our individual survival.

The independent is vital. First lets look at what the independent oil operator is, and what he and his kind have meant to the oil industry and to this nation.

It is important to remember that

"Independents who modernize their operations and up-date their thinking are the ones who will survive in the evolutionary weeding out process."

there are at least 10,000 independent oil operators in the U. S. The general public has heard of only a very few of these, and only the spectacularly successful ones, at that. It is easy, even for the people in the oil business, to forget that the operating and producing phases of this industry are composed of thousands upon thousands of small businessmen.

Independent operators drill three-fourths of all the wells. They drill more than 85 percent of the exploratory wells. I'm not unrealistic enough to suggest that without independent operators wildcatting would be cut 85 percent. But all of us know that were it not for the independent, exploration for oil in this country would be curtailed drastically.

Most of our nation's oil reserves have been discovered by independent oil men. And most of the reserves yet-to-be-discovered will be found by the independent operator. There can be little doubt that the basic health of the oil industry is determined to a large extent by the economic health of this vast army of independents. Our nation's defense machine runs on petroleum. Our defense capacity therefore, is related directly to the activities of the independent operators who will find the oil our nation will need today and tomorrow.

Men in high and responsible places in the oil industry know this. Men in high places in government understand it, too. Neither group will allow the independent oil operator to become extinct. They can't afford to.

But neither is it necessary that they mollycoddle him. The oil patch is not a protected playground. It's a tough world and a changing world. Not all the independent operators will survive the evolutionary changes that are now upon us. Those who *do* survive, and they will be the majority, I think, will be those who correctly read the writing on the wall and adapt themselves accordingly. Put even more simply, those who survive will be the independent operators who don't go broke, since it's *economic* survival we're talking about.

Economic threats. The economic threat to the independent is coming from several quarters. The most obvious current threat is the familiar bugaboo, imports. It is a plain fact that imported crude and products have displaced a considerable amount of domestic production. In the past two years the average daily allowable in Texas has been cut in half. Few business men in any industry could stay in business with half their income cancelled—and expenses rising. So far, the independent has been carried by his credit at the supply houses and the service companies and by a temporarily obliging banker. But it can't last forever. We all know that.

There is another potential economic threat from shale oil. It is only a question of time before billions of barrels of petroleum will be unlocked from oil shale at a price competitive with crude. Some informed men claim this condition already exists. In any event, it would be short-sighted, indeed, for the independent to ignore this economic threat. It's either here or it's coming, and soon.

As far as energy-per-dollar is concerned, the petroleum industry now competes with itself! Natural gas has taken markets from fuel oil, and will continue to do so until prices come more into a state of equilibrium.

For the more distant future new sources of energy are coming over the horizon, atomic and solar power. No matter what your personal estimate of when these energy sources will be competitive with petroleum, I'll bet you a new hat they come quicker than you think! It's all a question of economics.

Coal replaced wood because in the long run it was cheaper. Oil supplanted coal for many uses because it saved money. Oil lost some markets to gas for the same reason. Oil will lose customers as soon as another source of energy can do a job cheaper than petroleum.

Imported oil, shale oil, new sources of energy all pose a threat to the independent at the *dollar* level. So, to stay in the race the independent is going to have to *get more oil per dollar* than he does today. He is going to have to examine his operation with a microscope to find ways of doing a better job at less cost. And he will have to re-examine some of his pet theories and philosophies to make sure they mesh with the current facts of life!

Must be more scientific. The surviving operator will be the one who becomes more and more engineering wise. He will take advantage of every scientific advance. Finding and producing oil has become very much a science, as every man knows.

Yesterday's oil operator was characterized by the so-called "practical oil man." His engineering education was gained on the derrick floor and he learned his geology from cuttings. He came up the hard way, as he called it, and was proud of it. He was long on courage and hunches. Despite his scientific shortcomings, he found a lot of oil. He was inclined to run roughshod over the engineering school boll weevils he hired and frequently ignored the recommendations he was paying for.

Today's oil man is far more likely

"Imported oil, shale oil, new sources of energy, all pose a threat to the independent oil man at the dollar level."

to be a scientist, engineer or geologist, specifically trained and educated for the industry. This is the kind of independent operator who will or should apply every scientific principle that will make his operation more efficient and more effective. Together with other specialists in accounting and administration he will apply the knowledge that will enable him *to produce more oil per dollar* . . . oil that can compete with other sources of hydrocarbons and other sources of energy.

Wider well spacing. Besides examining our operations to make them more efficient, we independents also are going to have to re-examine some of our notions, to make sure they are not outmoded.

Let's take well spacing, for example.

Historically, the independent has been against wide spacing. Faced with the necessity for a fast payout, most independents have felt that the quickest way to increase their production was to drill a larger number of wells on his acreage. This concept may have been true to a degree in the past, but it is entirely erroneous today. It is one of the quickest and surest ways for the independent to price himself out of business under present conditions.

There was some reason to advocate close spacing back in the days of the $10,000 or even $20,000 wells, but it is eating us up today with development wells which frequently cost five or ten times that amount. It is very easy to invest more money in wells today than the total economic value of all the recoverable oil.

Present economic conditions require that we take a long, close look at proration practices. Producing allowables for the most part continue to be set on a per well basis. This has encouraged excessive drilling by making it appear that production can be increased by drilling more wells. This no longer is true. Under the practice of limiting production to market demand in many states, excessive drilling causes a reduction in per well producing rates. Actually, the more wells drilled, the smaller the production per well. Thus, our rate of return per dollar invested has been growing smaller and smaller. We now have reached a point where a continuation of this condition means the poor house.

Our allowable formula must be realistically and scientifically adjusted. Greater weight needs to be apportioned to acreage and to reserves so wells can be allowed to produce closer to their most efficient rate. The savings effected are obvious.

By producing at a higher rate with a reduced investment in a smaller number of wells, oil production operations can be made more economically feasible. This would permit more oil to be produced for every dollar of investment, thereby shortening the payout time. In this manner, the independent could stay in the economic race.

We are operating today, in most instances, under spacing concepts developed nearly a generation ago. In the meantime, reservoir engineering has made great advances. Independents in the '30s had reason to mistrust the scientific data available then when spacing rules were set. The situation is far different today. More data and more accurate data are available. Even of more importance, the independent is able to understand and appreciate it.

If we are to stay in the race, we must broaden our spacing ideas. Twenty acres may have been wide spacing for 5,000-foot wells, but it can make the development of a 15,000-foot reservoir an economic nightmare when the operator knows he could get just as much oil out on an 80-acre pattern at one-fourth the drilling cost.

Surely our scientific advances and our years of experience can enable the oil industry and the regulatory bodies to develop new spacing concepts which will be economically feasible and will also meet the individual and particular needs of the independents.

In all candor let me point out that this issue cannot be an irresolvable conflict between the independents and the majors. This is an issue that the industry as a whole is going to have to solve, if we are to keep domestic crude in the dollar race as an energy fuel.

Unitization another need. Wider and more economical spacing brings us to another concept on which the independent may well have to reappraise his position, if he is to survive.

I mean unitization.

With the wealth of experience and

"There was some reason to advocate close spacing back in the days of $10,000 or $20,000 wells, but it is eating us up today with development wells which frequently cost five or ten times that amount."

scientific information available, I have little doubt that the oil industry can find an equitable solution to this admittedly complex and often controversial issue. I will put that even stronger. I believe it is absolutely necessary that we find a solution, if we are to stay competitive. To get efficient spacing—to enable operators to institute appropriate money-saving automation techniques—to take full advantage of the scientific advances developed in research labs every day —to make secondary recovery projects possible—to squeeze the cost-per-barrel ratio as small as possible—a widespread broadening of unitization practice seems to be mandatory.

This may mean compulsory unitization or it may mean the establishment of official encouragement of voluntary unitization through proper incentives. I'm not prepared to offer the panacea. I just know that the survival of the independent depends on making all our operation as efficient as possible, and that unitization is a vital key.

Certainly it is possible that equitable unitization could be applied to new fields as they are discovered. And it is not inconceivable that it can be extended unto fields which have already been developed.

The basic problem is to find an application of the unitization system that will protect the rights of all concerned.

Application of the Law of Capture

"Surely in this age of science we need not base our production rules on the theory that oil is flowing under our leases in mighty rivers."

to oil production dates back to the days when the nature of petroleum reservoirs was completely misunderstood by the oil industry and by the courts. Because they thought rivers of oil ran in torrents beneath the surface of the earth in the same way that rivers of water flowed on the surface, the courts applied the same laws to both situations. Confinement and containment within an oil structure was not considered. Universal application of the Law of Capture to oil production gutted many a field and caused the unnecessary drilling of thousands of wells. Surely in this age of science we need not base our production rules on the theory that oil is flowing under our leases in a mighty river.

I am hopeful that a movement for intelligent unitization will develop from within the ranks of the independent operators themselves. I am hopeful that they will lead the fight for their own survival. I am enough of a realist to recognize that if we wait for the majors to take the lead, it will be that much more difficult to get the majority of independents behind it—for a long time at least.

I am hopeful that from the ranks of the independents will come a committee or a group to study this unitization problem. The success and the shortcomings of unitization programs and laws in all oil producing states should be examined and evaluated. From this research could very well come an equitable and workable proposal, perhaps suggested state legislation, which might become widely adopted through the Interstate Oil Compact Commission. This group also could be the moving force to promote acceptance of the program within the oil industry.

I know other independents who are thinking in these terms. Unitization is NOT incompatible with the independent's way of doing business. I feel certain that unitization is coming in one form or another. A program devised and promoted by thinking independent oil men is likely to protect their, as well as the industry's, interest.

I have always been particularly impressed with the workability and equity of the unitization program at Old Ocean, perhaps because I am most intimately acquainted with it. The fact that my efforts and recommendations were partly responsible for its consummation has been a matter of pride to me.

Old Ocean land and royalty owners formed a committee to meet with the operators' committee. They worked out all problems for the best interest of everyone concerned. The royalty committee retained me to advise it on technical aspect, and it retained legal counsel for the contractual aspects. Unitization was accomplished after months of arduous work, study and meetings. Unitization at Old Ocean has made possible the orderly development of a difficult field complicated by engineering and production problems that might not have been met without solid support of all concerned. Unitization of Old Ocean has resulted in ultimate returns to royalty owners, operators and the State of Texas that far exceed the amount which would have been recovered under a competitive, unrestrained drilling program.

Best of all, we cannot overlook the benefits gained by the consuming public from the establishment of efficient methods and money saving techniques. The consumer profits from lowest possible prices and from a dependable *domestic* supply. Our nation benefits, in many ways, because through proper production practices every possible barrel of oil is produced for a thousand important uses. Inefficient production practices can leave millions of barrels of oil in the ground—lost forever to the landowner, the operator and the consumer.

Must help himself. The American independent oil man is not dying out—not the good ones. His present status may seem shaky, and he may need some help. But the most important thing he can do is to *help himself*. Much of this can be done at the individual level. The independents who modernize their *own* operations and up-date their *own* thinking are the independents who will survive in the evolutionary weeding out process. Some of the self-help must be done collectively by the independents. I suspect we'll see evidence of that soon, not necessarily through any single formal group or geographic area, but through a real grass roots awakening to the need for collective and unselfish action on the part of a large number of realistic and thoughtful men.

The oil man who stands still will not long remain independent. The times move too rapidly. The independent oil man who adjusts to his environment will gain strength from it.

He will gain strength through change and stature from adversity. He will be the survivor in this evolutionary struggle. He will be the independent oil man of tomorrow!

—The End

About the Author

Michel T. Halbouty is a consulting geologist, petroleum engineer, independent oil operator and producer. He has been instrumental in discovering more than 30 fields and extensions in Texas and Louisiana, including many of noteworthy significance. A graduate of Texas A&M College, he received a B.S. degree in geology and petroleum engineering in 1930, and an M.S. in 1931. In 1956, he received the Professional degree in geological engineering, the first to be conferred by the college. Halbouty has written and published 50 technical papers on petroleum geology and petroleum engineering; one book entitled "Petrographic and Physical Characteristics of Sands from Seven Gulf Coast Producing Horizons," coauthored "Spindletop," which was published in 1952, and is coauthoring two books—"The Book of Oil" and "The Last Boom," a book on East Texas. Halbouty recently has broadened his activities by acquiring a large amount of acreage in Alaska.

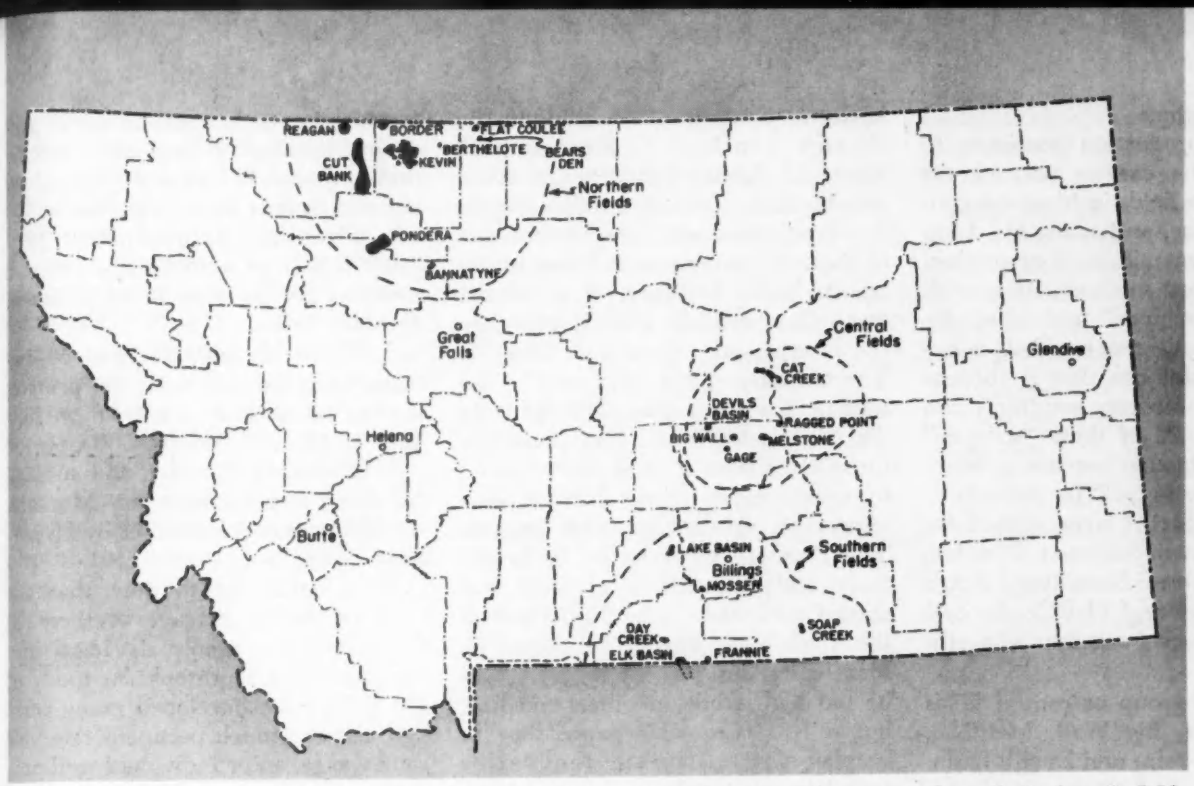


FIGURE 1—Index map of Montana showing the northern, central and southern grouping of "stripper" fields where secondary recovery is a good possibility.

Economics of secondary recovery in Montana

Increased reserves of 96 percent could result with successful application of secondary recovery methods

By Douglas H. Harnish, Jr., Chief, Petroleum Division,
Montana Bureau of Mines and Geology, Butte, Mont.

BY THE END of 1957, Montana had produced some 276.7 million barrels of crude oil, almost all of which was recovered by primary recovery methods. As an oil producing state, Montana contributes a little over 1 percent of the nation's crude production, ranking twelfth among the states.[1] Montana's production record shows intermittent high and low periods of production throughout the years with its present daily production higher now than it ever has been—some 75,000 barrels daily. (See Figure 2). The primary reason for this increase has been the development of the Williston Basin area in eastern Montana where three fields alone—Pine, East Poplar and Cabin Creek—yield more than half the present daily crude production. And if favorable political and economic conditions continue, production from the Williston Basin area should increase regularly for

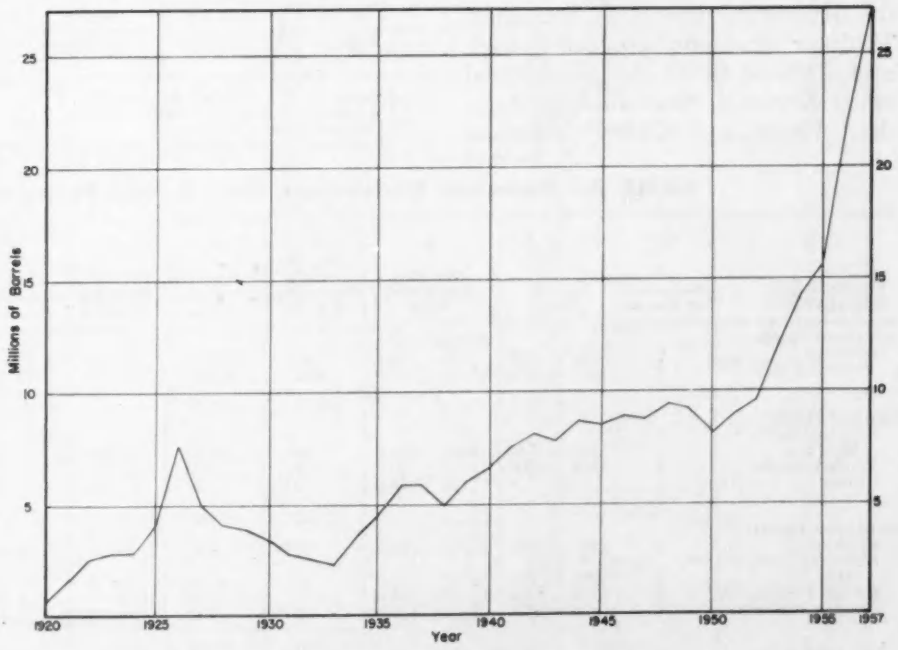


FIGURE 2—Montana's annual oil production. Recent large increase in production is due to the Williston Basin production.

some time to come.

As crude production continues to increase in the eastern part of the state, the older fields in Montana continue to decline, and many are at or near their economic limit of production by primary methods. It is with these older "stripper" fields that this study is primarily concerned. It is significant to point out that if successful secondary recovery programs can be applied to 22 of these "stripper" fields, a considerable increase in Montana's production will be realized.

The 22 fields that were studied are Cut Banks, Kevin-Sunburst, Pondera, Reagan, Border, Bannatyne, Bear's Den, Berthelote and Flat Coulee and have been grouped together as northern fields.

The second group or central fields are Cat Creek, Big Wall, Melstone, Gage, Ragged Point and Devil's Basin.

The third group or southern fields are Elk Basin, Dry Creek, Lake Basin, Soap Creek, Frannie, Mosser and Clark Fork. (See Figure 1).

Not all of these fields are considered "stripper" fields as, for example, Elk Basin which is presently producing at a rate well above a "stripper" state; however, this comparatively old field is approaching a period in which secondary recovery is being considered by the operators of this field.

To reduce statistical detail, fields in each of the three categories have been consolidated into producing horizons. Because producing characteristics and reservoir conditions are similar, the northern fields are incorporated into the Kootenai sandstone and Ellis-Madison limestone producing horizons. Central fields are incorporated under Kootenai, Morrison-Ellis, Amsden, Heath and Kibbey producing horizons. Southern fields include the Frontier sandstone, Cretaceous-Kootenai, Embar-Tensleep and Amsden-Madison formations. (See Figure 3). Production and reserves statistics of these three areas are shown in detail in Table 1. Reservoir properties and other variables used to calculate the reserves are reported in Table 2. The majority of the data used in the statistical analysis was obtained from the Montana Oil and Gas Conservation Commission records and adjusted to some degree where further data were available through other sources. The ultimate recovery by both primary and secondary recovery was chosen arbitrarily to be 50 percent of the stock tank barrels in place. In some cases this percent recovery will be too high while in others too low, but it is a reasonable expectancy in keeping with ultimate recoveries found in other areas.

From an over-all viewpoint, not considering each area or each producing horizon or field as a specific study or analysis in itself, the following conclusions have been made:

1. There are approximately 327,700,000 bbls. of secondary oil reserves available for recovery in Montana in 22 older fields.

2. These 327,700,000 bbls. of secondary oil compare with the primary reserve estimate for the state on January 1, 1957, of 343,400,000 bbls.

3. Therefore, effective and successful secondary recovery in Montana would increase the reserves by 96 percent.

It is significant to note that the total producing acreage of these 22 fields is about evenly divided into limestone and sandstone. As many of the fields were developed many years ago, not too much pertinent reservoir data was taken or individual well production records kept. This factor, plus the division of reservoir rock proper-

TABLE 1—Production and Reserves by Producing Horizons, January 1, 1958
THOUSANDS OF STOCK TANK BARRELS

1 PRODUCING FORMATION	2 Orig. Oil in Place	3 Cumulative Production 1/1/58 est.	4 Ultimate[1] Recovery all Methods	5 Ultimate[2] Primary Recovery	6 Possible[3] Secondary Recovery	7 Possible[4] Reserves 1/1/58 est.	8 Ratio: Secondary / Primary
Northern Fields							
Kootenai	522,271	78,041	261,135	93,368	167,767	183,095	1.80
Madison-Ellis	354,693	86,774	177,347	107,435	69,912	90,572	.65
	876,964	164,815	438,482	200,803	237,679	273,667	1.18
Central Fields							
Kootenai-Ellis Morrison	76,012	19,066	38,006	20,734	17,272	18,940	.83
Amsden-Heath	18,070	4,468	9,035	5,544	3,491	4,567	.63
Kibbey	1,841	534	921	552	369	386	.67
	95,923	24,068	47,962	26,830	21,132	23,893	.79
Southern Fields							
Frontier	15,462	1,560	7,731	3,864	3,867	6,171	1.00
Kootenai-Cretaceous	31,562	4,363	15,781	7,293	8,488	11,418	1.16
Embar-Tensleep	107,292	11,628	53,646	26,822	26,824	42,018	1.00
Amsden-Madison	118,823	13,068	59,411	29,705	29,706	46,343	1.00
	273,139	30,619	136,569	67,684	68,885	105,950	1.02
Total—All	1,246,026	219,502	623,013	295,317	327,696	403,510	1.11

[1] Based on 50% of S.T.O. in place.
[2] Extrapolated Decline Curves.
[3] Column 4 minus Column 5.
[4] S.T. barrels available by all methods on 1/1/58.

TABLE 2—Reservoir Dimensions, Rock & Fluid Properties, January 1, 1958

1 PRODUCING FORMATION	2 Number of Fields	3 Depth Feet	4 Net Pay Thickness Feet Range	Ave.	5 No. of Wells Producing 1/1/57	6 Estimated Proven Acres	7 Porosity Percent	8 Water Saturation Percent	9 Formation Volume Factor	10 Gravity °API	11 Primary Recovery Bbls./Acre Ft.	12 Secondary Recovery Bbls./Acre Ft.
Northern Fields												
Kootenai	6	1450 to 2400	7–39	15.1	980	49,470	12–16	30–43	1.05–1.13	26–38	125	225
Madison-Ellis	4	1500 to 3200	6.5–15	7.8	1895	52,655	14–20	30–45	1.07–1.15	32–38	261	170
					2875	102,125						
Central Fields												
Kootenai-Ellis-Morrison	1	1100 to 1750	6–51	33.8	98	2,120	18–21	19–40	1.10	52	286	241
Amsden-Heath	4	1200 to 6000	11–25	20.3	34	1,360	10–17	30–64	1.02–1.09	19–34	200	126
Kibbey	1	4400	28	28.0	3	140	11	40	1.09	34	141	235
					135	3,620						
Southern Fields												
Frontier	2	1200 to 6700	28–97	53.9	21	320	14–21	29–43	1.16–1.29	45–67	224	224
Kootenai-Cretaceous	3	1000 to 5800	12–30	18.9	16	3,116	11–24	22–35	1.01–1.6	22–52	124	144
Embar-Tensleep	2	2700 to 4900	29–166	158.5	33	1,456	10.5–19	8–35	1.02–1.57	27–29	116	116
Amsden-Madison	2	1825 to 6215	12–224	126.5	36	1,730	11.6–19	10–35	1.08–1.12	17–35	135	135
					106	6,622						
Totals—All	25				3,116	112,367						

ties between sand and lime, will cause great difficulty in evaluating the possible mechanics and subsequent success of a secondary recovery program.

However, these difficulties should not deter aggressive operators from taking necessary steps to evaluate each field's possibilities. To overcome deficiencies of production history and reservoir data, a definite, formal and comprehensive research program should be initiated by those concerned. The urgency of starting the program now is obvious—to prevent the wholesale abandonment and plugging of the present producing wells which will soon reach their economic primary limit.

These wells, of course, will have their use, either as a producer or injection well in a secondary recovery operation. Necessary legislation has already been enacted to allow secondary recovery and the governing laws are quite capably administered by the Montana Oil and Gas Conservation Commission.

Even though several pilot operations have been tried and a few actual injection programs are in operation, secondary recovery on the whole has not yet contributed very much production to the states' total.

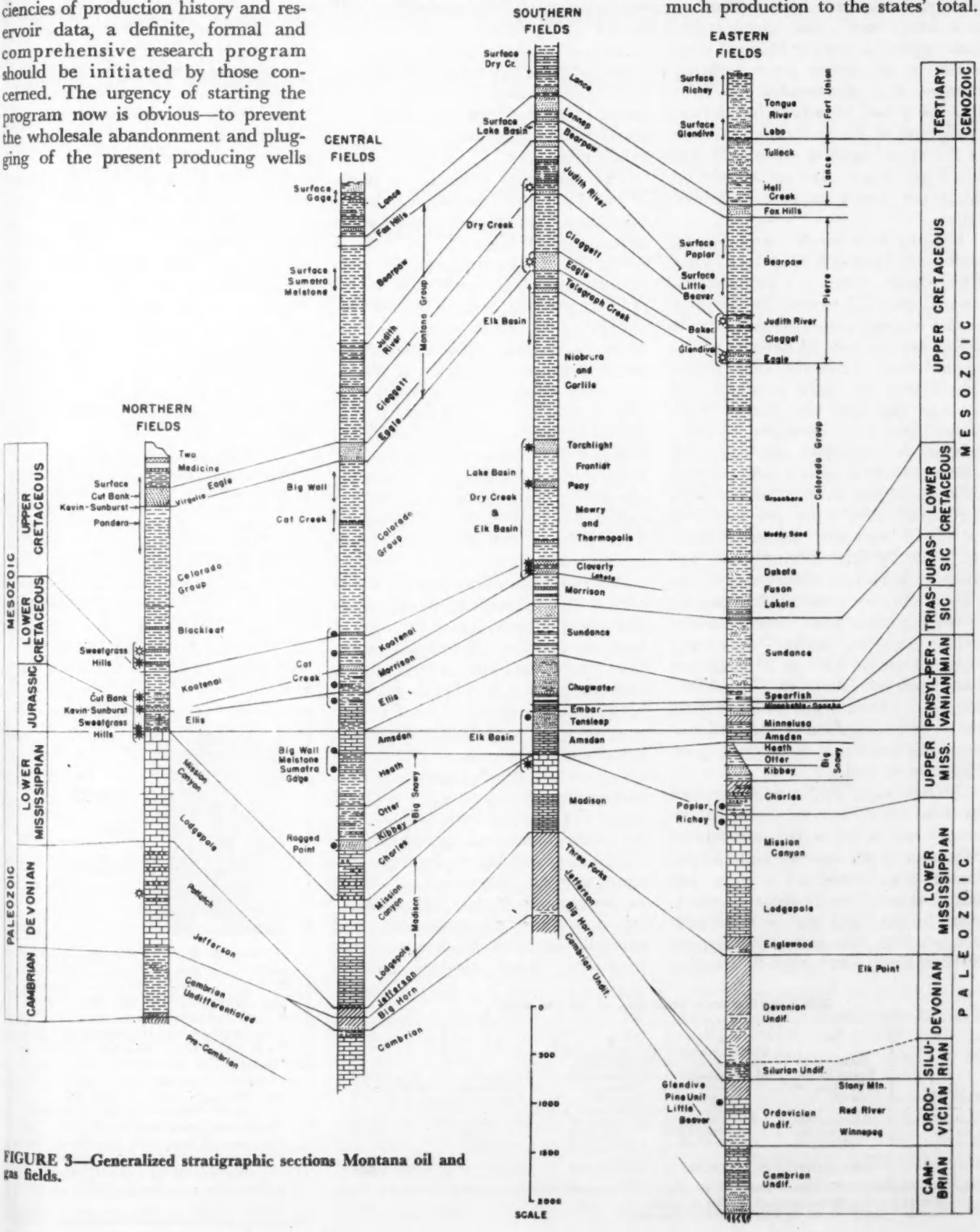


FIGURE 3—Generalized stratigraphic sections Montana oil and gas fields.

Many areas where secondary recovery could and should be instituted have been summarily condemned as unfeasible because development costs appear to be almost as great as the value to be received.

One main deterrent against initiating secondary recovery either before primary limits have been reached or as a final resort is that operators feel their capital money can be spent more wisely in developing future primary reserves. It is questionable how wise this policy may have been in the past, According to H. J. Struth,[2] the cost of finding a barrel of oil in 1956 was $1.11 per barrel, but an average of $2.55 per barrel on new, unproved oil.

Looking at it another way, finding costs have increased 61 percent since 1951 while crude prices have increased only 12.5 percent for the same period of comparison. Actually, crude prices are up only 22 percent at the present time above the 1951 prices. The figures are based on a national average that only one out of eight wells drilled was a producer. In 1957, Montana's frequency was only one out of 16! This would indicate that wildcat drilling in Montana is costing considerably more per barrel of oil found than the national average of $2.55. Wildcat drilling, then, apparently is a losing proposition at the present time in eastern Montana.

On the other hand, successful secondary recovery projects often produce oil for as little as 10 cents per barrel increase above its normal lifting cost. Therefore, it would appear that a reinvestigation of formerly uneconomic secondary recovery projects might be in order.

At this point, it also might be well to show the effect that secondary recovery will have on the economy of Montana. If the average of $2.85 per barrel gross (weighted average per barrel value of the 22 fields) is multiplied by the 327.7 million of secondary reserves, the gross value equals $942 million. One-eighth royalty equals $117,750,000. To develop the gross of $942 million many more Montana people will be employed and many other Montana industries will share in this total such as suppliers of power, cement, steel and equipment.

Not the least affected either will be the State of Montana which will collect almost $59 million in taxes based on 18 cents per barrel. (See Table 3). The tax figure of 18 cents per barrel is based on a study of the personal property, net proceeds, oil production, conservation, and corporation taxes.

The significant point to be made is that if successful secondary recovery operations were started very soon the bulk of this money would be realized within 20 or 30 years from the time of inception of the operations.

What must be done to initiate secondary recovery on a full scale in Montana? Primarily it will require organization and cooperation of all interests involved in a given area. This implies that there is need for unitizing the fields, having one operator to administer and conduct the operation, since many fields are presently being worked by many individual interests. Before the final method or program to be followed can be decided, many studies will have to be performed.

Some of the studies will have to ascertain the saturations of oil, water and gas presently remaining and if possible a material balance made. Core analysis will have to be made to find the answers to relative permeability, effective porosity and other reservoir rock properties. All possible laboratory techniques should be investigated along with pressure-volume-temperature studies to learn the fluid properties existing, both initially and presently. Structural characteristics, thickness, producing mechanisms, oil-water and gas-oil contacts all should be determined. In fact, all engineering data must be consistently and carefully analyzed to determine the geological factors involved such as inter-well communication, fracture zones and faulting if it exists.

Results of a comprehensive engineering study will determine the mode or method of secondary recovery to be used, be it water-flood, crestal gas injection, LPG injection, in situ combustion or a combination of several methods. Pilot operations may precede the method decided upon to verify and substantiate the engineering study. Some methods may prove failures—at least economically. But if the oil saturation is sufficient, the means and manner to recover it will be found.

In summary, it appears that Montana's oil reserves could be almost doubled by a successful secondary recovery program with a gross income of nearly a billion dollars being realized. Consequently, direct taxes to the State of Montana will approach $60 million. However, none of the aforementioned could be accomplished by an industry that did not enjoy the keenest kind of competition or adhere to the strictest ethical principles of business.

TABLE 3—Economic Valuation of Oil Production

1 FIELDS	2 Estimated Gross Value of Production to 1/1/58	3 Undiscounted Gross Value of Remaining Reserve 1/1/58	4 Undiscounted Gross Value of Secondary Reserve 1/1/58	5 Tax Value of Remaining Reserve	6 Tax Value of Secondary Reserve
Northern.....	$280,426,000	$817,991,000	$710,423,000	$49,260,000	$42,782,000
Central.....	43,991,000	57,248,000	50,632,000	4,301,000	3,804,000
Southern.....	60,313,000	278,119,000	180,823,000	19,071,000	12,399,000
	$384,730,000	$1,153,358,000	$941,878,000	$72,632,000	$58,985,000

Columns 3 and 4—Based on present price of crude.
Columns 5 and 6—Based on $.18/bbl. present tax rate.

ACKNOWLEDGMENT

The writer would particularly like to acknowledge the Montana Oil and Gas Conservation Commission for their kind cooperation in allowing access to their records and facilities and to the Montana Bureau of Mines and Geology Memoir No. 35, "Oil and Gas in Montana" by E. S. Perry, from which much general data was taken but not heretofore mentioned as a reference.

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About the Author

Douglas H. Harnish, Jr., graduated from the University of West Virginia in 1943 with a B.S. in mining engineering. His first job in the oil industry was in the Production Engineering department of The Pure Oil Co. in Illinois and West Virginia. He worked for Dowell Incorporated as service engineer and was research engineer for the University of West Virginia, Engineering Experiment Station. In 1954 he was named associate professor and head of the Petroleum Engineering department, Montana School of Mines, the position he holds at the present time.

PART 2: Modified theory of salt movement

New look at salt dome geology may increase Gulf Coast reserves

Here are facts that may cause a revision of present exploratory drilling procedures on salt domes

By **V. N. Sovinsky**
Consulting Geologist, Houston

ALTHOUGH A DETAILED regional correlation of the Gulf Coast salt dome province still is far from completion (so far only 100 structures are more or less tied together), important phenomena are apparent.

At least 11 sedimentary cycles can be recognized in the Miocene. If a complete cycle is present at a well, the maximum thickness of the sedimentary column is ±2,100 feet. Except in two instances this figure is practically the same for every cycle, indicating more or less comparable rates of sedimentation throughout the Miocene. The composite log of sediments younger than Oligocene (provided each known maximum of the sedimentary column is considered) is about 30,000 feet thick. It is encouraging to notice that this figure does not vary much from that postulated by prominent geologists.

Usually, only the lower part of the sedimentary column of each cycle is present in a well located on structure. The thickness of a sedimentary column of each successive cycle penetrated in the same well is variable, indicating a different rate of growth of the structure during each cycle. Sometimes almost complete deposition during one cycle is present, although the previous or following cycle will be represented only by a lower part of the sedimentary column. Although some sort of pulsation in salt movement can be perceived, this is only an illusory sensation. If less attention is directed to an over-all picture and more attention is paid to movement during each successive cycle (as an independent entity), successive rejuvenations of the structure by movements of different magnitude can be perceived.

Growth of salt structures. The facts mentioned above (especially the fact that only the lower part of each sedimentary cycle is present at each well located on a structure) require an explanation. The logical explanation is to assume that salt structures are dormant at the beginning of each sedimentary cycle. After some sediments accumulate on top of the structure, the salt is triggered upward. This movement continues without interruption to the end of the cycle.

While the growth of a structure is in progress, the differential rate between salt movement and deposition of sediments will govern the final type of structure created. Three types of movement can be visualized:

Case 1. Rate of movement is slower than rate of deposition. In this case, there will be a convergence of sand and shale streaks from the flanks toward the top of a structure.

Case 2. Rate of movement is equal to rate of deposition: Here there will be a pinchout of sands and shales.

Case 3. Rate of growth is faster than rate of deposition: Besides some pinchout, a definite doming effect will be evident.

In the last case, the depth of the sea will be of paramont importance. When water depth is less than 75-80 feet, the bottom of the sea will remain essentially flat. Therefore, instead of a doming effect, there is a truncation of sediments by submarine erosion, and a local unconformity is created. It is easy to prove that such truncation exists through study of a detailed Coast and Geodetic Chart of the Gulf Coast. Many shallow salt dome structures on land have a surface topographical expression. The Coast and Geodetic Chart indicates some structures protruding from the bottom of the sea in deep water. However, the many structures existing where water depth is less than 75 feet show no bathymetrical expression.

It is obvious that the areal extent of a local unconformity will be directly proportional to the rate of vertical uplift of the salt and inversely proportional to the slope of the flanks of the salt.

So far, the growth of structure has been discussed without considering a possible act of salt piercement. In Case 1, piercing is not possible. In Case 2 if salt pierced the sediments in the previous cycle it will remain exposed until the end of the successive cycle.

A most interesting point is the case of growth of structure when rate of movement is faster than rate of depo-

sition. Here, although only the remaining effects of piercement can be observed the time and type of piercement can only be perceived. If piercement has not occurred in a previous cycle, its presence in a successive cycle will require piercement of the layer of sediments accumulated at the beginning of the new cycle and of the layer left on the top of the structure during the previous cycle. Probably, a small piercement occurs during each successive cycle.

If a hypothetical cross-section consists of wells exhibiting a thin sedimentary column during one cycle, an almost complete section during the next cycle and a thin column again during the successive cycle, it is obvious that piercement occurred at the end of the last cycle with a vigorous uplift of the structure. The result is an enormous truncation of sediments below and above the last cycle. Stratigraphic traps were created below local unconformities, provided the flanks of the salt were not too steep at the beginning of the movement.

The stratigraphic traps below the sediments of the last cycle are toward the top of the structure. This is precisely where industry now is drilling to find oil accumulations. On the contrary, the stratigraphic traps *on top of the last cycle* are mostly toward the flanks of the structure, not toward the salt. These traps are largely overlooked and never probed thoroughly.

It is easy to explain why this occurs. If a flank well is drilled and turns out to be a dry hole, few will dare to recommend a new location downdip. Even if another flank well is drilled, it could pass the line of the local unconformity between the sands or hit an unproductive sand. A special effort should be made to probe along the lines of local unconformities; sometimes toward the salt, sometimes toward the flanks. The exact procedure should be determined by the rate of movement during each individual growth cycle of the structure. (See Figure 2.)

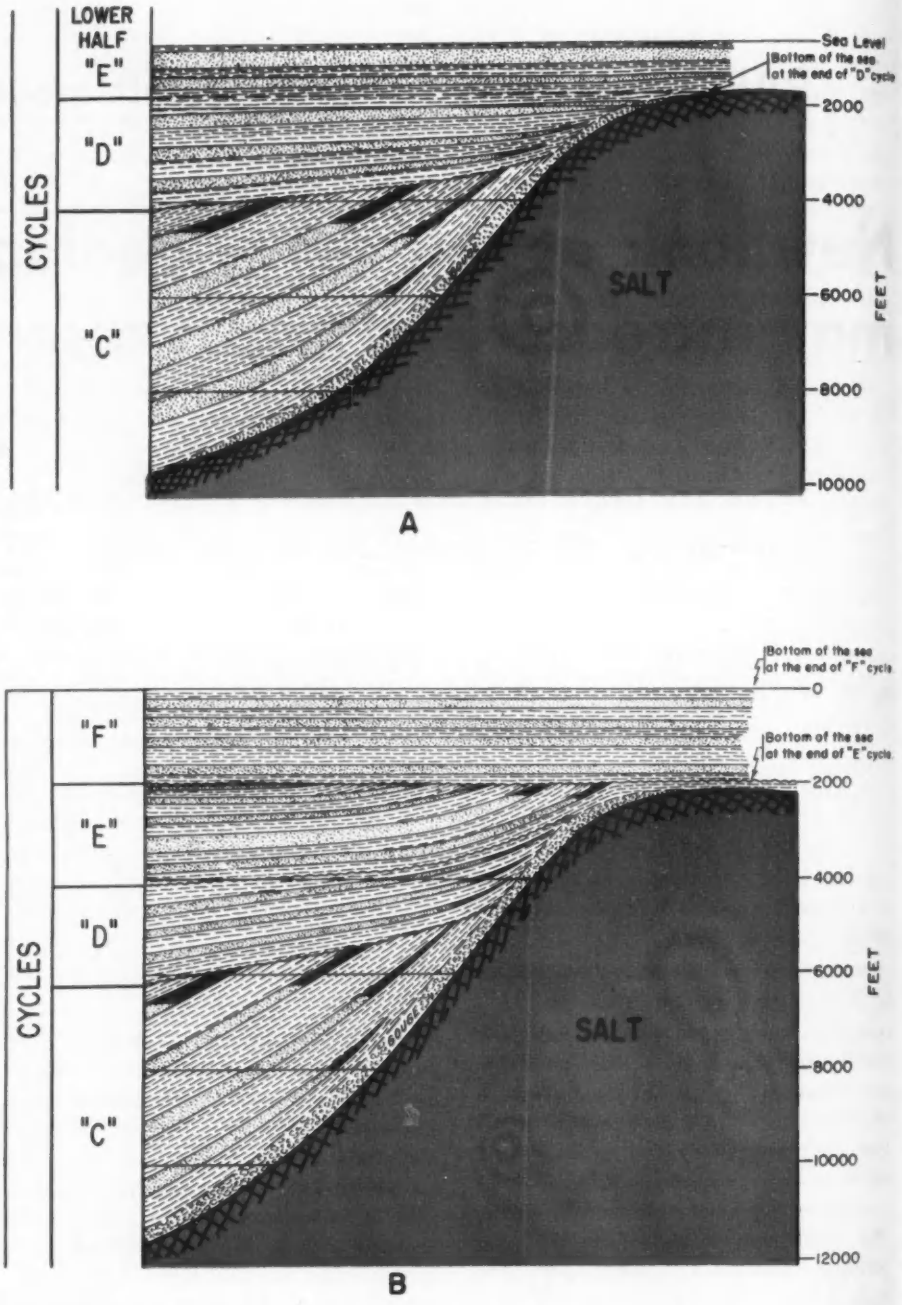
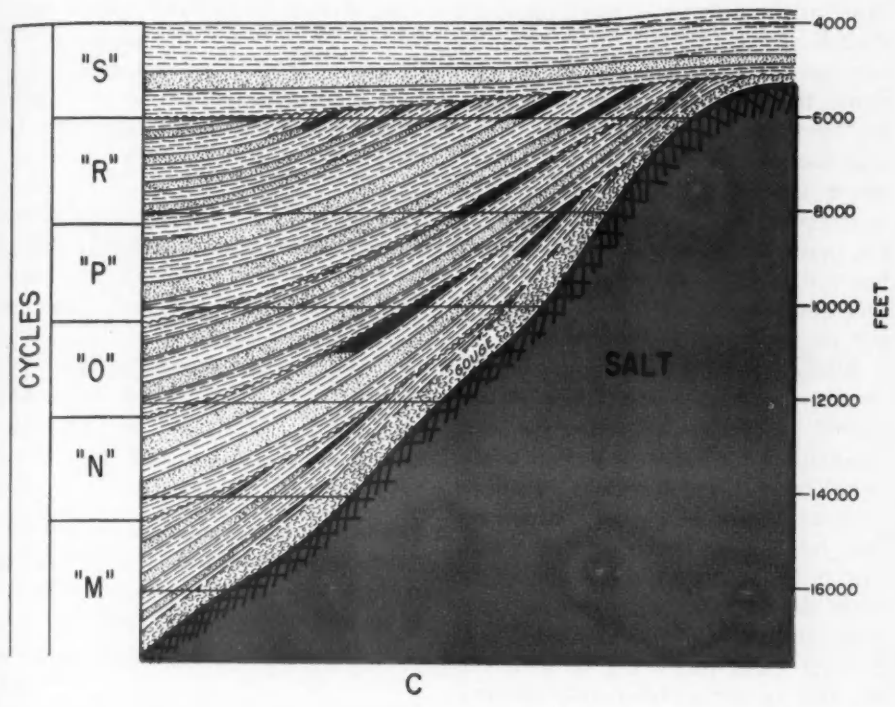


FIGURE 2—These schematic drawings show locations of possible stratigraphic traps on the flanks of salt domes. Plat A indicates vigorous growth of the dome during deposition of sediments older than the D cycle. Slow growth is indicated during deposition of the D cycle. Dormancy predominated during deposition of the lower half of the E cycle. In Plat B, conditions are the same as in Plat A for the D and older cycles. Compar-

Modified theory of salt movement. In the author's opinion, the difference in density between salt and sediments can explain adequately only the movement and existence of salt pinnacles with vertical flanks in the sea of sediments. The moment a study shifts to salt structures having flanks sloping with dips as low as 35 degrees, the need to evolve a modified theory involving tectonics is imperative.

The principal reason for denying the existence of compressive stresses in the Gulf Coast area is the supposition of tectonic quiescence of the salt dome province. The present-day conception that the Gulf Coast area is a unique place in the world where tectonics do not play any part is not acceptable to the author. If mother salt is 5,000 feet thick (as many believe), then it acts like a rubber mat absorbing tangential stresses of the basement rocks. Instead of transmitting force to the upper rocks, it releases the stress by corrugating the salt. It is not tectonic quiescence but only the lack of tectonic manifestations, such as observable folds, that is apparent. A structural map of the Gulf Coast area shows at least three different trends in the alignment of salt structures. This is a manifestation of tectonics. Therefore, some modifi-



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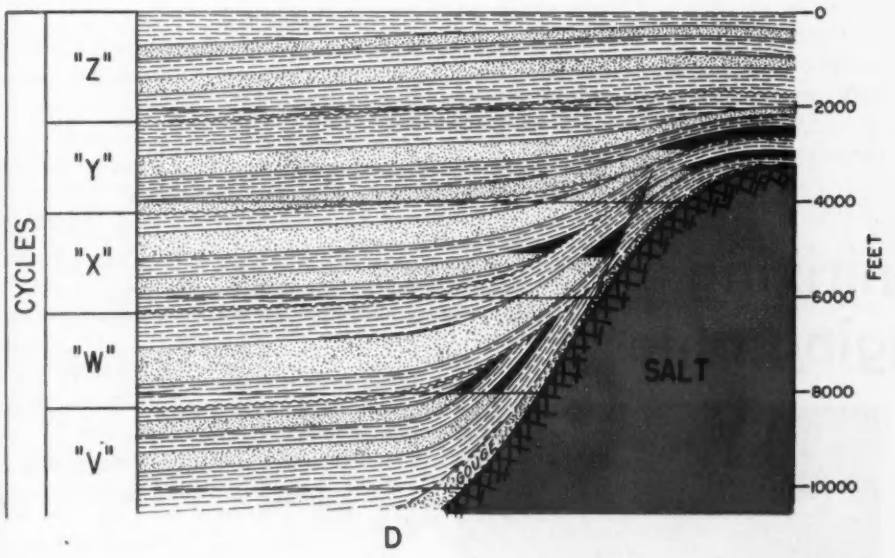


D

atively fast growth is indicated during the second half of cycle E. Dormancy is indicated during cycle F. Plat C indicates slow growth of the dome during cycles M, N and O; dormancy during cycle P; and vigorous growth during cycle R. Very slow growth is indicated after the end of cycle R. In Plat D, a deep sea is indicated at the end of cycle W. The structure protruded from the bottom of the sea during cycle X.

cation of the theory of salt movement is suggested.

Assuming that a new cycle of sedimentation starts after the adjustment of basement rocks has been completed, a period of time when tectonic stresses in the area are at equilibrium can be perceived. Also, this is a period when salt movement exhausted its forces reaching the surface at the end of the previous cycle.

It is conceivable that some slight movement of the salt, or even of the structures, is possible on buoyancy of salt alone. However, this movement is of a creeping nature rather than actual growth. New blanket sands or shales are spread over the whole area covering the tops and flanks of old salt structures where the depth of the sea was less than 75 feet and, at first, only on the flanks of the structures that were protruded from the bottom of the sea in deeper waters. It seems that some lag of time (probably as long as half of the cycle) is necessary for new stresses to accumulate in the basement rocks before additional tectonic forces can be released to act as a trigger for a new upsurge of salt. As soon as this occurs, old structures are rejuvenated. Also it is probable that a group of new structures is created.

Possibly, the horizontal components of stress might be from different directions during different cycles with new structures elongated in new directions. In this case, old structures might be deformed on the flanks so that shoulders will appear. Also, it is possible that some old structures are not rejuvenated at all and become deep-seated domes, while others skip a cycle without a vigorous movement.

It is true that the stress may be relieved by gravity faulting, but at the same time the existence of the Sigsbee Fault and the fault west of Florida, (both of which are suspected of being slip faults) should not be overlooked. If these two slip faults—and there may be more than these two—should become active only once in 1.5 million years, which is roughly the duration of each cycle, tangential stress must exist in the area. If this is so, not only the corrugation of mother salt is possible, but also a periodic rejuvenation of this corrugation is definitely conceivable.

With the preceding in mind, the following picture can be visualized: at first, when the overburden was only a few thousand feet thick above mother salt, the tangential stress (which accumulated during the time of deposition of the overburden) was released partly by a corrugation of the salt and partly by a slippage along the border slip faults. A number of short ridges located "en echelon" was created. Submarine erosion leveled the protruding tops of the ridges and domes while the structure creeped upward due to buoyancy of the salt alone.

While this creeping continued, blanket sands and shales were deposited until enough stress accumulated for rejuvenation of the old structures and creation of the new. Because the creeping process kept the salt from being buried too deep, a sudden upsurge of energy (during rejuvenation) caused piercement of the comparatively thin layer of sediments on top

of the structure. With this release of stress, a new quiescence prevailed, and, again, blanket sands and shales were deposited throughout.

The described process was repeated so many times that now the whole mother salt is thoroughly corrugated and the structures look like the Empire State building—with a broad base at the bottom, then shoulders and a smaller structure on top. The process continues until a pinnacle stage is reached.

This is not presented as a final answer to the problem. Others may suggest a better one. The main point is that periodic compressive forces in basement rocks are essential for the creation of the type of salt structures now present in the basin.

Differentiation of structures. All salt structures are classified by the depth of burial of the salt or by types (piercement or nonpiercement domes). Oil accumulation on salt structures is classified as a combined structural and stratigraphic trap. The normal and accepted practice in oil search is to look for oil on the top of deep-seated structures or immediately close to the salt at a piercement or shallow dome. All structures actually are lumped together—the larger the dome, the better the prospect of finding large accumulations of oil.

If the idea of periodical salt movements instead of continuous growth is accepted, it becomes apparent that the main factor is not vertical uplift but the mode of creation of a structure and the dip of the slopes of the salt mass.

Gentle structures without too much closure (with closure lines widely spaced) probably will have the best accumulation close to salt. Few additional traps in the truncated sands on faraway flanks will exist. Structures that have enormous closure (with closure lines closely spaced) also might have oil near the salt. However, the main and most prolific accumulation in these cases might not be near the salt but at a considerable distance down the flanks of the structure. This is easy to explain.

If growth is too fast, only basal sands of each cycle are present on a high structural position. The majority of sands of the upper part of each cycle either were not deposited or were eroded. However, these sands should be present on flanks of the structure. This does not mean that each flank sand will carry oil—it only means that these sands could not be tested in a well located too high structurally.

It should be remembered that resemblance between anticlines and salt structures is only superficial. As soon as it is realized that a salt structure is primarily a stratigraphic trap, it is obvious that one or several dry holes do not condemn the structure as barren. This fact only indicates that the geological picture is not yet solved properly.

Exploration procedure. Present-day exploration procedure is derived from years of experience on anticlinal structures and around salt domes with vertical slopes. Recently deep drilling has proved that the majority of the salt structures have a salt mass dipping at some angle less than 90 degrees at depth.

If the hypothesis of the growth of the salt structures postulated previously is correct then exploration methods for salt structures requires some unorthodox modification in procedure to fit this new concept.

When producing sands are separated by intervals much thicker than the sands proper and when dip is steep, the chance of finding a prospective producing sand in a favorable position below an unconformity is approximately one out of five. In other words, four drilling wells out of five will pass through the unconformity in a wrong place and may be abandoned as dry holes.

The present exploration procedure (when initial drilling is high structurally) does not permit the decipherment of the existence of local unconformities until completion of a considerable number of additional wells. Therefore, it is impossible to take a special precaution not to bypass a possible reservoir. It is too expensive and, therefore, not practical to probe around each sand, and the drilling is done completely in the dark.

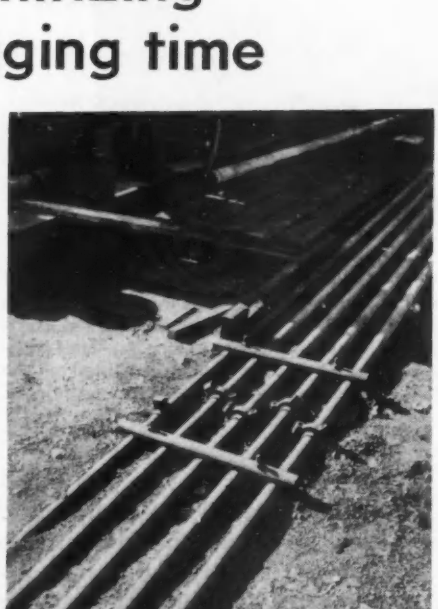
But when unconformities are established already, an operator can probe, with a very small additional expense, around one or two sands and discover a producer instead of a dry hole.

ACKNOWLEDGMENT

The ideas expressed in this article are not all original and could not have been developed without the many helpful suggestions of fellow workers in Gulf Oil Corporation's Houston Production division.

This simplified unitizing system saves rigging time

Unitizing of service lines need not involve precise cutting of all pieces to exactly the same lengths or clamping them together with elaborate or rigid mounts. One company found that a simple system such as that illustrated adequately serves the purpose. Cost of unitizing is held to a minimum as mill length joints are used. Joints are clamped together so sufficient room is left to make up the quick-acting unions. A pair of notched pieces of 2-inch pipe, equipped with two bolts, provides the clamp holding the several lines together and at the desired distance apart.



Simplicity of the spacer-clamp device permits easy removal of any joint that may be damaged accidently, or made ineffective by scale or corrosion. Ease of loading and unloading, coupled with the saving in time in rigging up at each location, easily pays for the unitizing of the lines. Numbering or color-coding the ends facilitates matching of the units when they are made up each time.

See page 64 for other practical operating hints

Drilling controls discarded in steeply dipping formation

British-American has found that 'uncontrolled directional drilling' pays off in faster penetration rates, less rig time and lower costs

By Harold J. Reedy, Division Geologist
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THE METHOD for directional drilling described here is termed uncontrolled because no mechanical aids, such as whipstocks or knuckle joints, are used. Variation of weight, speed of rotation, and surface hole location afford the only control.

In most drilling contracts, hole deviation is limited to five degrees from vertical. The deviation limit may be reached quickly where steep dips are encountered. The drilling contractor must hold up on the drilling weight to keep the deviation from becoming greater than the specified five degrees, which would result in a lower rate of penetration.

Lower penetration rates increase costs of drilling the hole for the operator and/or the drilling contractor. A plant to allow for a greater hole deviation is necessary if the drilling cost is to be reduced. If the direction and amount of drift are known under normal drilling conditions, the surface location can be moved to compensate in the proper direction and to arrive at the desired point at the objective horizon. Deviation restrictions in the drilling contract can be relaxed to a point which will be sufficient to prevent rapid changes in direction which might result in key seats and fishing jobs.

This method of directional drilling was used in staking the surface location for the British-American Oil Producing Co.'s Harrison 2, Section 29-T3N-R5W, discovery well for the deep Bromide sand production of the Carter-Knox field, Grady and Stephens counties, Oklahoma. The well was completed Feb. 14, 1956, for a calculated open flow potential of 31,000 Mcfgpd with 5,022 barrels of condensate. The surface location of this well was staked approximately 1,000 feet down dip from the desired location at total depth.

The hole was controlled to 1 degree deviation per 1,000 feet of depth. At 10,000 feet the hole could have a total deviation of 10 degrees and 15 degrees at 15,000 feet. All Bromide sand wells have been planned in the same manner since this discovery. The hole deviation is now being controlled to 1 degree per 1,000, down to 6,000 feet and 1½ degrees per 1,000 feet from this point to total depth.

Geology Carter-Knox field. Southern Oklahoma is an area of difficult and complicated geology. It has been subjected to extreme folding, faulting, uplift and erosion. Many sharp anticlinal folds were deeply eroded especially during the Pre-Atoka-Post Morrow period. Many structural features show deep erosion between the Deese and Hoxbar periods. It is common to drill through either of these unconformities into beds with much steeper dips. The Carter-Knox structure suffered its greatest erosion after the Hoxbar period.

The Carter-Knox Pennsylvania structure is an elongate faulted anticline. Figure 1 is a structure map contoured on top of the Woods sand. The small circle represents the surface location; the double circle is the bottom hole location at the Viola limestone horizon and the cross is the bottom hole location at the Woods sandstone horizon.

There is evidence of dip into the fault on the northeast flank. The dip on the southwest flank is 50 to 60 degrees which flattens to 30 degrees. No well has been drilled to the Springer east of Fault A (Figure 2). From seismograph information, it is estimated to be at —9,800 feet. Since the top closure west of Fault B is at —1,500 feet, in excess of 8,300 feet of relief is present on the Woods sand horizon in a horizontal distance of 1,500 to 2,000 feet, most of which is the result of thrust faulting.

The Pre-Pennsylvania structure is an anticlinal fold parallel to and approximately one mile west of the Woods sand structure. The deep structure appears to be asymmetrical as steeper dips have been encountered on the northeast flank than on the southwest flank. The Krieger 1, Section 3-2N-5W, is the highest well in the field. It is 263 feet higher than the Harrison 2, Section 29-3N-5W, and has recorded dips of 18 degrees to the southwest at the bottom of the hole, indicating an even higher structural position to the northeast in Section 3. The dips in the bottom of the hole of the Harrison 2 and the Teter 1, Section 18-3N-5W, show these wells to be very near the crest of the deep structure, the axis of which is shown by Figure 1.

Figure 2 is a subsurface cross-section across the structure and through the Harrison 2 discovery well. The dashed line near the Harrison 2 shows

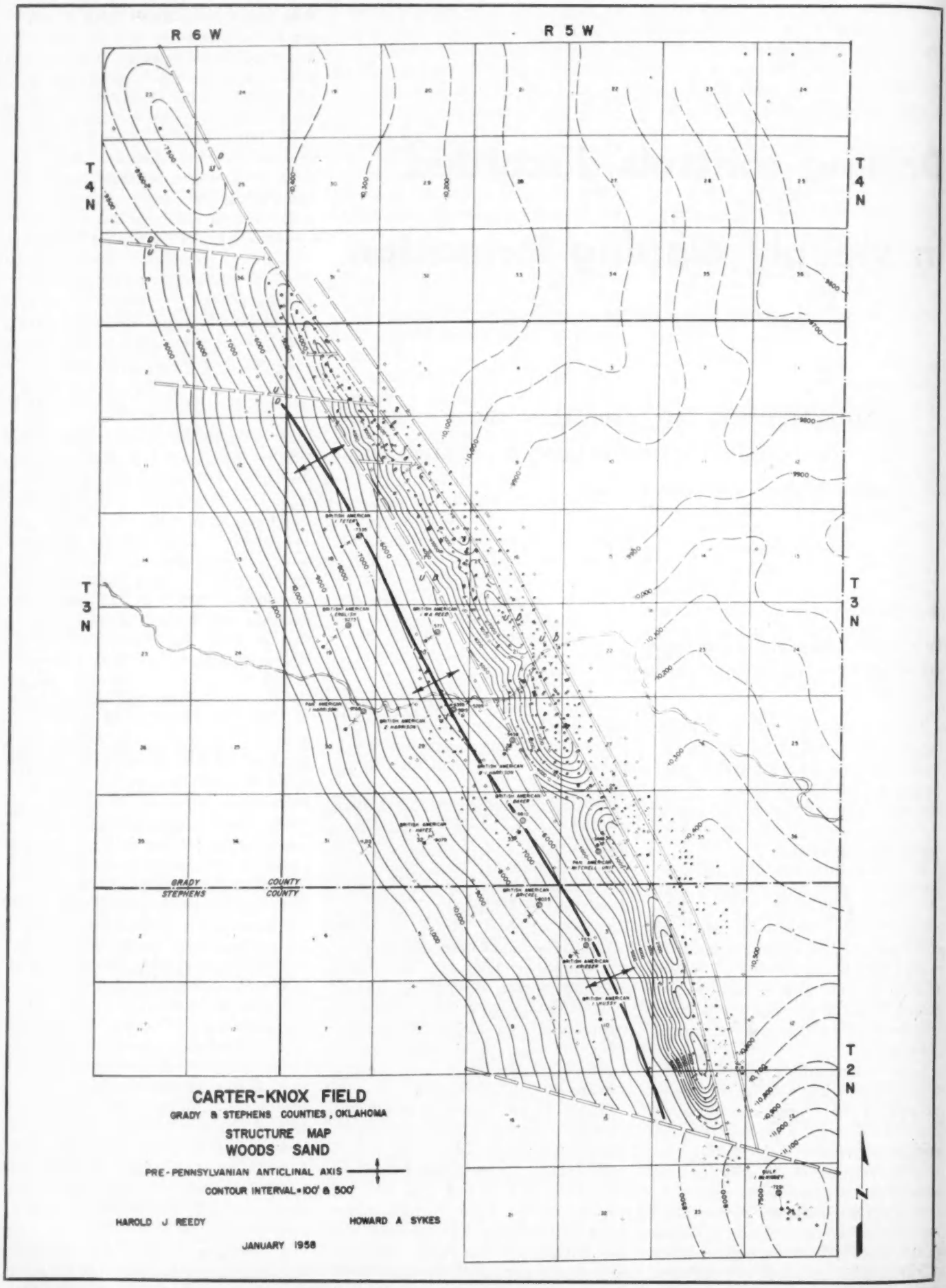


FIGURE 1—Contours of the top of the Woods sand in Carter-Knox field. The small circle represents the surface location, the double circle is the bottom hole location in Viola limestone and the cross is bottom hole location in the Woods sandstone.

The target area is selected on the objective horizon . . .

the section view of the well bore. All formation tops are plotted on this dashed line. The second dashed line is the section view of the well bore for the Harrison 1-B, Section 28-3N-5W which is projected into the cross-section along strike. Note that both of these holes began to straighten up when dips change from southwest to northeast. This dip change occurred below Fault Zone C in the Harrison 2 and below Fault Zone B in the Harrison 1-B.

Selecting the target area. Target Area is defined as a square, rectangle or circular area on the objective horizon. It is desired that the subsurface course of the well, while aiming for the central target point, shall intersect the objective horizon within this prescribed target area.

In all wells drilled at Carter-Knox for Bromide sand production, a well recommendation is made giving a prognosis of formation tops, surface location and a target area for the bot-

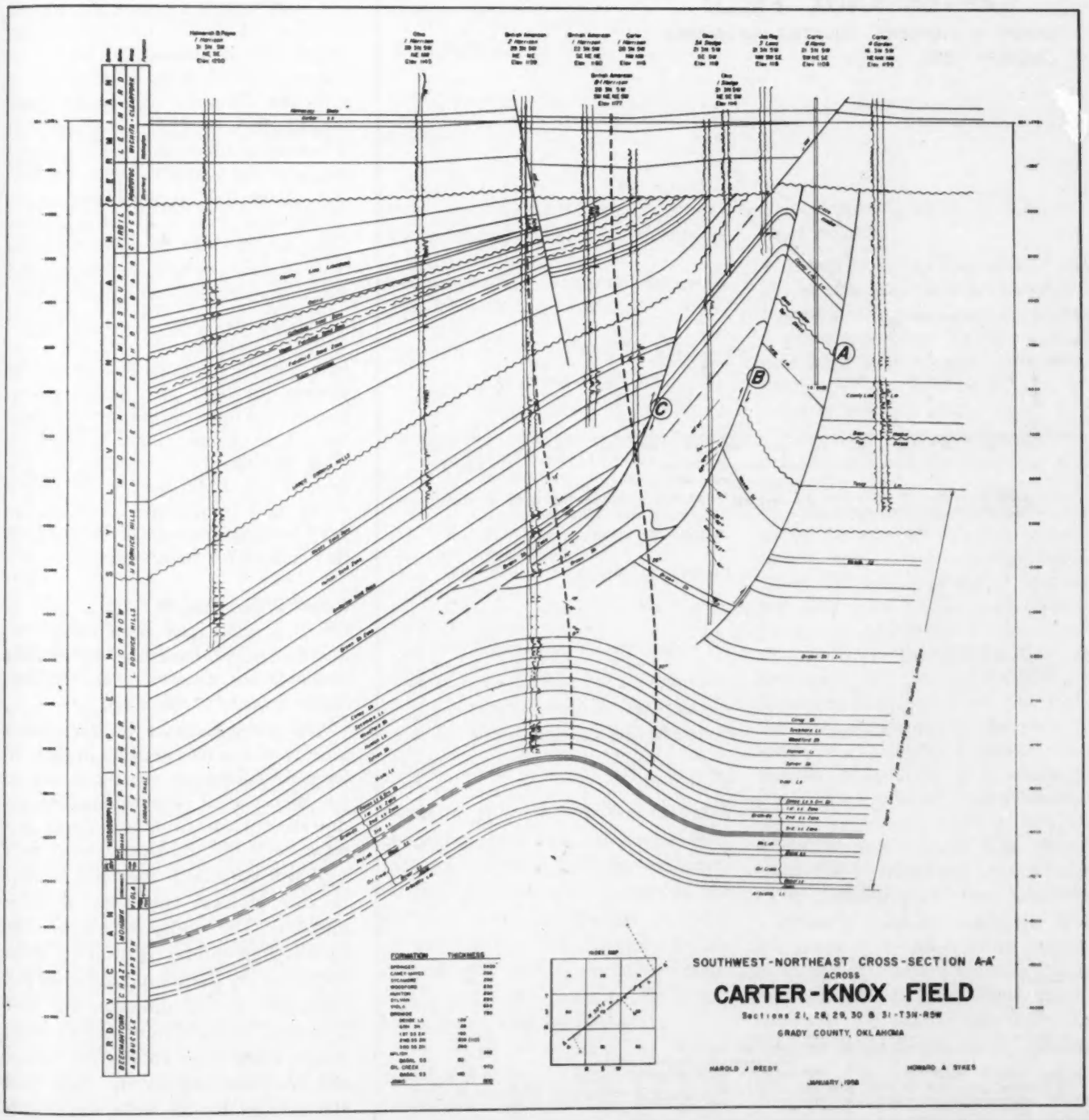
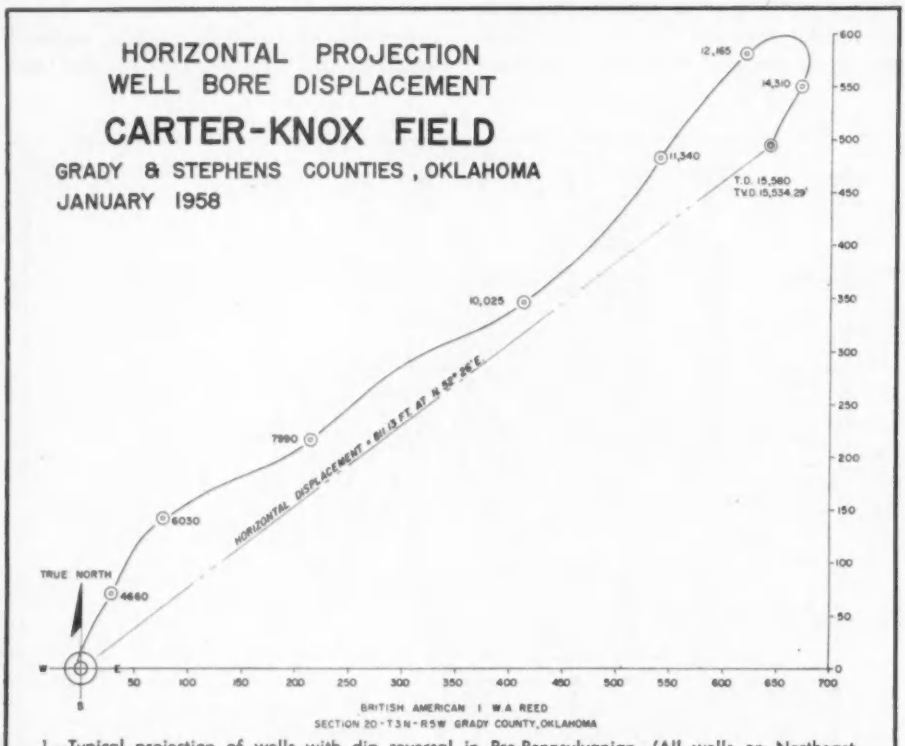


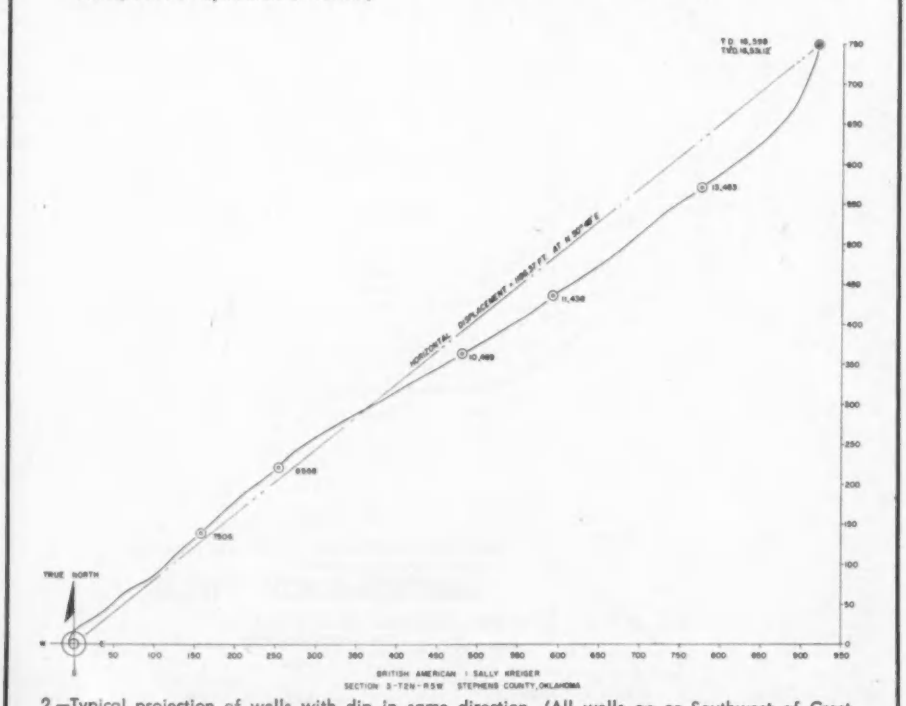
FIGURE 2—This is a subsurface cross-section across the structure and through the Harrison 2 well. The dashed lines are section views of all the well bores. All formation tops are plotted on the dashed line. The second dashed line is a section view of the well bore of the Harrison 1-B, which is projected into the cross-section along strike. Both holes began to straighten up when dips changed from southwest to northeast.

TABLE 1—Hole Survey Data on Wells in Carter-Knox Field

WELL NAME	Location	Horizontal Displacement	Direction	Maximum Deviation	Depth of Maximum Deviation	Bottom Hole Deviation	Strike Direction Springer Formation	Updip Direction Computed	Variation From Updip
Harrison No. 2	Sec. 29-3N-5W	962′	N 48° E	10¾°	11550′	¾°	N 33° W	N 57° E	9° L
Reed No. 1	Sec. 20-3N-5W	811′	N 52° E	10¾°	11340′	3¾°	N 22° W	N 68° E	16° L
Krieger No. 1	Sec. 3-2N-5W	1186′	N 51° E	9¼°	11770′	3¾°	N 27° W	N 53° E	12° L
Brickel No. 1	Sec. 4-2N-5W	1139′	N 41° E	10¼°	11672′	8°	N 35° W	N 55° E	14° L
Baker No. 1	Sec 33-3N-5W	1010′	N 27° E	9¾°	10263′	3¼°	N 44° W	N 46° E	19° L
Harrison No. B-1	Sec. 28-3N-5W	837′	N 30° E	14¼°	10968′	3°	N 32° W	N 58° E	28° L
Teter No. 1	Sec. 18-3N-5W	1060′	N 54° E	11°	11090′	2¾°	N 25° W	N 65° E	11° L
English No. 1	Sec. 19-3N-5W	1844′	N 51° E	15¼°	12137′	5°	N 23° W	N 67° E	12° L



1.—Typical projection of wells with dip reversal in Pre-Pennsylvanian. (All wells on Northeast Flank, Pre-Pennsylvanian Structure.)



2.—Typical projection of wells with dip in same direction. (All wells on or Southwest of Crest, Pre-Pennsylvanian Structure.)

FIGURE 3—Bottom hole locations, on or southwest of, the Pre-Pennsylvania axis, in the Carter-Knox field, have a displacement in the same direction (Illustration 2). A well northeast of the axis will have a displacement pattern similar to Illustration 1.

tom hole location. Since the well spacing is 640 acres, with the location in the center of the NE/4 of each section, the target area is usually designated as the 40 acres in the center of the NE/4. This provides a square area, 1,320 feet by 1,320 feet in which it is desired to have the bottom of the hole placed. An area this size proved ample for the depth and drilling conditions encountered.

Selecting the surface location. After the target area has been selected and the direction of dip determined, the next step is to stake the surface location. To do this, the center of the target area is assumed to be the location of the bottom of the hole. A sufficient distance is measured down dip, to allow the hole to be drilled in a normal manner and the horizontal displacement updip to place the bottom of the hole at the center of the target area. This is an arbitrary distance which must be selected on the basis of depth of hole, experience and contract restrictions on hole deviation.

For the Harrison 2, the discovery well, this distance was 1,000 feet. The hole actually migrated 962 feet in the proper direction. The drilling contract called for a deviation not greater than 1 degree per 1,000 feet drilled. Had the contract provided for 1½ degrees per 1,000 feet, more weight could have been carried and the desired horizontal displacement of 1,000 feet could have been attained.

Results obtained. At the present time, six wells have been completed, and two, which have hole survey data available for analysis, are drilling. Table 1 contains this data.

The average strike in the central portion of the field is N 30 degrees W from the subsurface structure map on the Woods sand (Figure 1). The updip direction computed from this strike is N 60° E. Updip from each well will vary from the field average because of local variations of strike and dip. The updip direction, for each well, is computed from the strike measured on the subsurface map and compared to the direction the hole deviated. The variation, for all wells, ranges from 9 to 28 degrees left of the computed updip direction, and the average for all wells was 15 degrees to the left. All variations are left of the updip direction, and from

Continued on Page 172

Here's a straightforward nomograph for . . .

Calculating recoverable oil reserves

Determine recoverable oil reserves by applying this easy-to-use nomograph. Methods of obtaining each factor involved in the recoverable reserve formula are presented

By Dan H. McLendon, Division Sales Engineer,
Lane-Wells Company, Dallas

THE EVALUATION of an oil producing property is a process which generally is separated into two phases—engineering and economic. The engineering phase seeks to determine as accurately as possible the amount of recoverable oil or gas along with the daily rate of oil production to an economic limit or abandonment. A value can be placed on the production when the production rate and amount of recoverable oil or gas is known. This is the economic phase.

An oil reservoir is best described as a pressure vessel containing rock having connected pore spaces that are filled with oil and water. The type of reservoir, along with quality of the reservoir rock, will determine the percent of oil recoverable. The amount of gas in solution in the oil under reservoir conditions will determine the formation volume factor. With the above data, one can estimate within reasonable limits the stock tank oil under the lease.

Factors involved in the classic formula are porosity, oil saturation, formation volume factor and recovery factor. Since the nomograph goes further, thickness of the oil-saturated producing section and surface acres of property being considered for evaluation also are incorporated. No discussion of structural position or secondary recovery is included since those two subjects introduce considerations beyond the scope of this paper.

Recoverable reserve formula. The formula is as follows:

$$\text{Recoverable Bbls. Stock Tank Oil} = \frac{\phi \times S_o \times 7758 \times R \times h \times A}{FVF}$$

where ϕ = Porosity in decimal equivalent
S_o = Oil saturation in decimal equivalent
7758 = Conversion factor (There are 7,758 barrels in one acre-foot)
R = Recovery factor in decimal equivalent
h = Thickness, in feet, of effective pay
A = Area under consideration in acres
FVF = Formation Volume Factor

Each of these factors will be discussed and the various sources from which each is obtained will be described briefly.

Porosity (ϕ). The fraction of interconnected space occupied by the bulk material not filled by the solid framework of the material is known as the porosity. This is the storage capacity of the material and usually is expressed as a percentage of the bulk. The porosity of a rock can be found by various means, as follows:

• **Core Analysis.**[1] Several excellent methods are used for this determination. Generally, all in present use are most reliable.

• **Neutron Log.** This method is for use in carbonate reservoirs having intergranular or small vugular porosity. A neutron log can be obtained in a hole filled with conductive, non-conductive, or no fluid at all and in a cased or uncased hole.

Since the neutron measures hydrogen saturation of the rock unit in the proximity of the instrument, it can be described as measuring fluid saturation, because all fluids encountered in oil and gas production contain about the same amount of hydrogen per unit volume. The rock unit explored by the neutron is composed of the bore hole (fluid-filled or dry) and formation with porosity fluid-filled by filtrate or formation fluid. The higher the fluid saturation in the rock, the lower the neutron response. Conversely, dense rock or gas-filled porosity (having lower fluid saturation) shows high neutron deflection and reads far to the right. The neutron curve can be calibrated to read porosity by correlation with core porosities.[2]

When plotted on two-cycle, semi-log paper with the neutron response in inches or standard units as abscissa and core porosity as ordinate (on the two-cycle log scale), the points fall along a straight line. The apparent porosity of a particular shale and the porosity of a dense zone can be de-

Nomograph on following two pages . . .

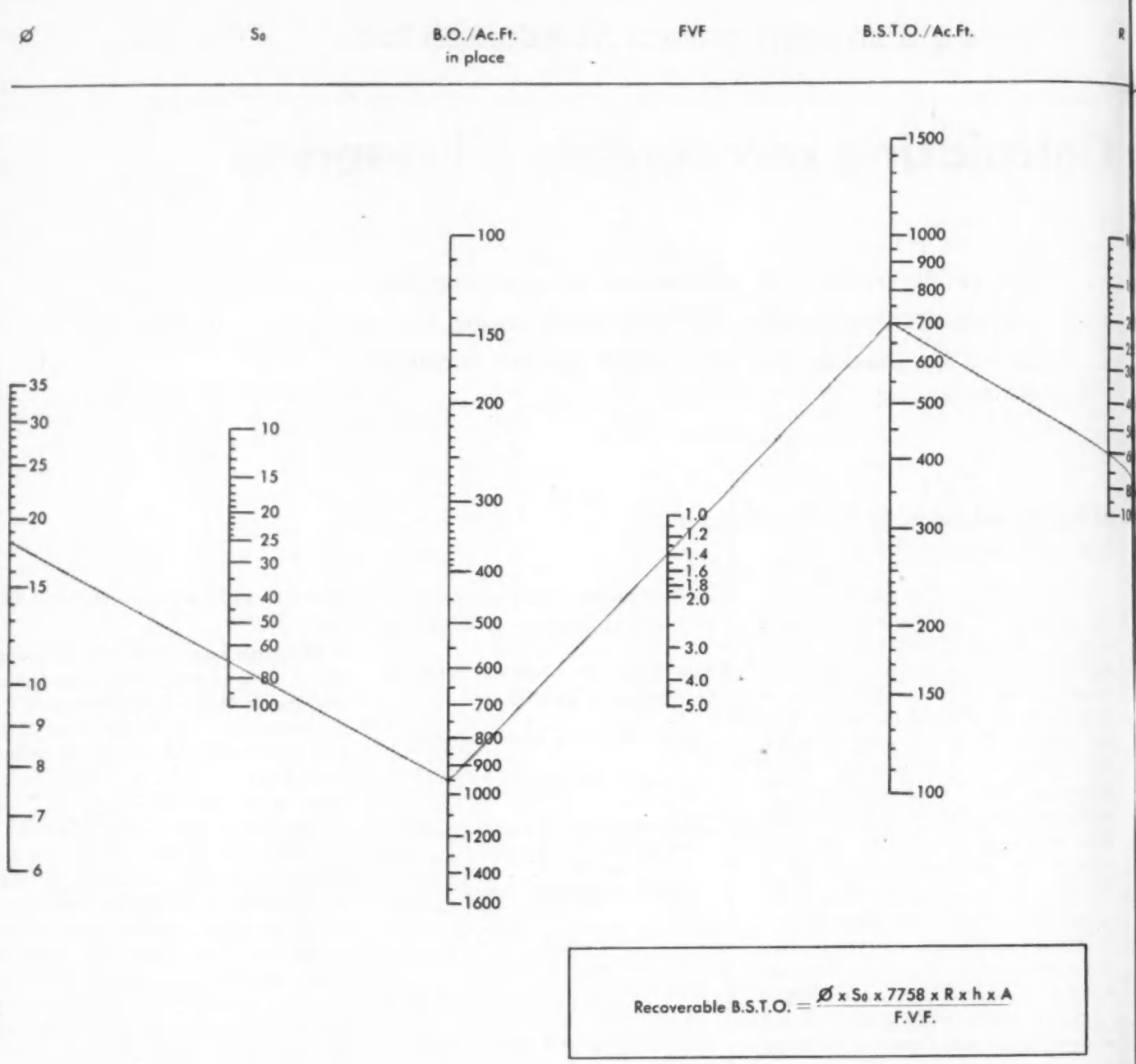


FIGURE 1—The nomograph for calculating recoverable oil reserves is illustrated. Example: A 160-acre lease has 20 feet of oil sand with 18 percent porosity and an oil saturation of 70 percent. The formation volume factor is 1.4 and recovery factor is 60 percent. By applying the nomograph solution shown, recoverable oil reserves are 1,350,000 barrels.

termined from the curve. If these persist over an area with little lithologic change, subsequent neutron logs can be calibrated to read porosity by merely scaling off the interval between these predetermined limits with a logarithmic scale.

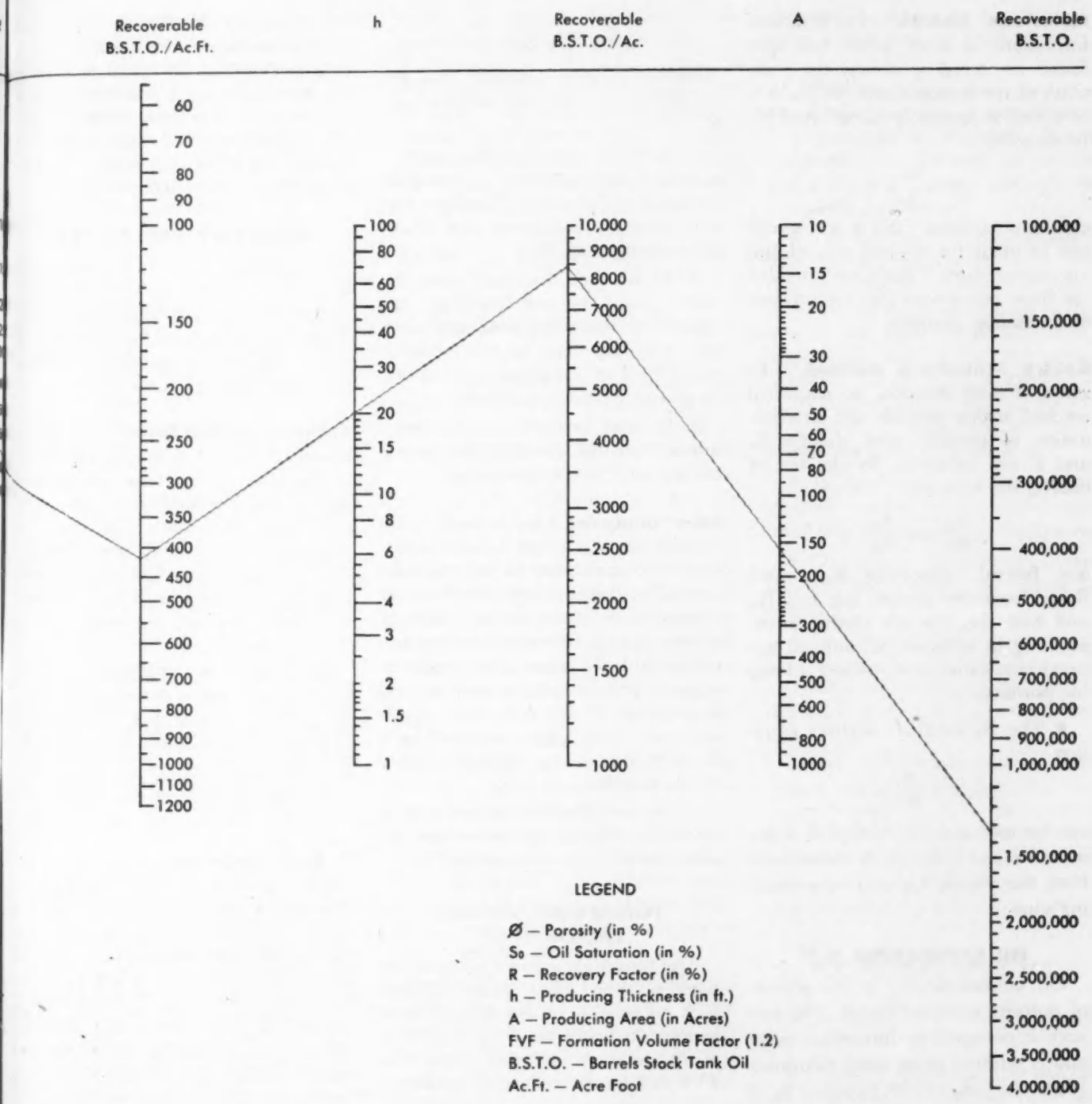
Considerable effort has been devoted to preparing a list of fields over the country in which the apparent shale porosity and dense porosity have been determined. This work is continuing because of interest shown by the industry.

Based on experimental data, neutron logs of the Geiger-counter type can be calibrated to read fluid-filled porosity in clean formations. Charts relating counts per second and porosity for various hose sizes have been published.[3, 4]

Contact-type logs. The microlaterolog[6] measure R_{xo} (the resistivity of the bore hole) when the mud cake is less than ⅜-inch thick. Since this zone is practically flushed of all formation fluids, it is assumed to contain only filtrate from the drilling mud in a salt-water-bearing sand. In an oil sand, however, a small amount of residual oil is present and a correction factor is used. Finding the value of R_{mf} (resistivity of the mud filtrate) at the formation temperature is done by the use of charts that relate R_m (resistivity of the mud) to R_{mf}. The Formation Resistivity Factor (F) then is determined by using the equation

$$F = \frac{R_{xo}}{R_{mf}}$$

which is valid in water-bearing for-



LEGEND

Ø — Porosity (in %)
S_o — Oil Saturation (in %)
R — Recovery Factor (in %)
h — Producing Thickness (in ft.)
A — Producing Area (in Acres)
FVF — Formation Volume Factor (1.2)
B.S.T.O. — Barrels Stock Tank Oil
Ac.Ft. — Acre Foot

mations. This is a variation of

$$F = \frac{a^{7}}{\phi^{m}}$$

where ϕ is porosity and a and m are parameters based on the nature of the formation. Solving the above gives porosity.

The microlog[8] is obtained by the contact tool. This tool measures the resistivity of small volumes of material near and behind the wall of the bore hole. The two-curve system is used primarily to locate zones of porosity.

It has been shown that a valid relationship exists between $R_{2''}$ (resistivity value recorded with 2-inch micronormal device) and porosity from cores. These empirical data are available.

• Focused current devices. In areas where the salinity of mud filtrate is unusually high (Kansas), regular resistivity curves are adversely affected. Current is focused so as to flow radially into a narrow slice of formation and is prevented from escape up and down the bore hole.[11] In a water-bearing zone, R_o (the resistivity of the formation completely saturated with salt water) is read directly from the log. If the resistivity of the formation water (R_w) is known, F is found by using the equation:

$$F = \frac{R_o^{(7)}}{R_w}$$

Published charts easily convert F into ϕ. In popular use as a graphic representation of the Humble Formula:

$$F = \frac{0.62^{m}}{\phi^{2.15}}$$

Limestone lateral.[13] In limestone formations, a short lateral has been found to record accurately the resistivity of the invaded zone (R_i) where invasion is generally deep. Archie's relationship

$$F = \frac{R_i}{R_m}$$

can be considered valid if corrections can be made for residual gas, oil and interstitial water. Charts are provided for these corrections and for solution of formation porosity.

Rocky Mountain method.[14] In zones of deep invasion, an empirical method makes possible the determination of porosity even though R_o and F are unknown. By the use of charts, the value of

$$\frac{R_i}{R_m} \text{ and } \frac{R_t}{R_m}$$

are found, knowing $R_{16''}$ and $R_{1'8''}$ from the electric log and R_m and hole size. Tixier's charts, incorporating in addition SP and an approximate value of K, permit solving for porosity.

• The R_o method. Archie's equation

$$F = \frac{R_o}{R_w}$$

can be used directly to find F if R_w is known and if R_o can be determined from the electric log in a water-bearing sand.

OIL SATURATION (S_o)

Oil saturation (S_o) is the percent of porosity occupied by oil. The balance is occupied by interstitial water and is referred to as water saturation (S_w). $S_o + S_w = 100$ percent. S_w is found as follows:

Electrical surveys. Several combinations of curves can be used under different conditions and all determine the value of R_t (true resistivity of the formation). Archie has shown that:

$$S_w = \sqrt[n]{\frac{R_o}{R_t}}$$

where n is the saturation exponent and R_o the resistivity of the formation completely saturated with water. Since

$$F = \frac{R_o}{R_w} \quad R_o = FR_w$$

Substituting for R_o, above:

$$S_w = \sqrt[n]{\frac{FR_w}{R_t}}$$

Under various conditions the following systems are used to determine R_t:

1. In thin, clean, fairly porous sandstone, the induction log and short normal may be used.[6] The short normal corrects for invasion and allows determination of R_t.

2. In salt mud, focused-current devices (guard log and laterolog) can be used to record apparent resistivities that are very close to true resistivities.[15, 16] The references list limitations and cautions to observe.

3. In thick beds, R_t can be determined from the conventional electrical log and "departure curves."

Core analysis. One procedure in current use is referred to as the semi-permeable membrane or restored-state method of determining connate water saturation. It measures the ability of a core sample to retain water when subjected to forces (air pressure) equivalent to natural gravitational segregation of oil and water in a reservoir. The water retained is a function of pore size and homogeneity of the sample.

There are several other methods of measuring capillary pressures that are quite accurate in determining S_w.

FORMATION VOLUME FACTOR (FVF)

The formation volume factor is the space occupied by a barrel of stock tank oil with its produced gas placed in solution under reservoir conditions of temperature and pressure. The FVF can be determined as follows:

1. Formation fluid samples. These can be obtained by wireless methods with a special type of sampling device. Formation pressure can be obtained by gaging the sampler at the surface, temperature can be read from a maximum temperature thermometer and the amount of gas and oil recovered at surface conditions can be determined by examination. The nature of the gas and oil can be determined by analysis and the volumes can then be converted to reservoir conditions.

2. The Katz method. This method is based on analysis of produced gas and oil to determine how they existed in the reservoir.[17]

3. Gas/oil ratio. If only the gas/oil ratio is known, a fair approximation of the FVF can be found by taking the base figure 1.05 and adding to it the value 0.05 for each 100 cubic feet of gas produced. For example: a well having 500 GOR will have 1.3 FVF, since $1.05 + (5 \times 0.05) = 1.3$.

RECOVERY FACTOR (R)

The percent recovery is determined by several factors, most important of which is the producing mechanism. There are three basic mechanisms by which oil can be recovered from a formation through a well bore.[18]

1. Dissolved Gas Drive. This mechanism consists of a simple expansion of the gas released from solution in the oil near the well bore when pressure drop takes place. Gas bubblets, migrating to the well bore through the formation, carry along oil droplets. No free gas cap or water source is present. Average recovery is from 10 to 40 percent.

The degree of cementation of the reservoir rock has a pronounced effect on recovery in this type of reservoir. Highly cemented sandstone yields low recovery.

Loose, unconsolidated sands yield high recovery.[19]

2. Gas Cap Drive. This is essentially displacement of oil from the sand by downward expansion of a free gas cap. The oil is said to be saturated (with gas). As long as only the oil section is allowed to produce, initial reservoir energy (gas cap pressure) is conserved. The downward sweeping of the gas cap forcing the oil toward well bores is quite efficient when it is recognized that gravity is aiding this mechanism. Under this type of drive 30 to 80 percent of the oil might be recovered.

3. Water Drive. This process is upward displacement of oil by influx of water from below the oil sand. Water may get its drive from being artesian in nature with a continuous permeable sand outcropping in an area where rain falls frequently. The drive also may come from expansion of the water occupying the reservoir sand in its extension away from the oil-bearing portion.

Water is only slightly compressible; but when it is realized that for every barrel of oil in a reservoir there may

be 10,000 barrels of water, the water need not be very compressible to provide an effective driving mechanism for the oil. Range of recovery for water-drive fields is from 45 to 85 percent. Wells should be completed as far from the water/oil contact as possible unless other considerations dictate a different procedure.

Several other factors affecting recovery require mentioning. Low-viscosity oils are more mobile and more readily produced: the lower the viscosity, the higher the recovery. Highly permeable sands give greater recovery than low-permeability sands. These factors might be found useful to determine in what portion of the recovery range a particular reservoir should fall.

This is the only factor in the reserve formula that is not determined by laboratory work or study of well data and logs. A study of the area geology, other fields of the area, and well performance data must be made before a reasonable recovery factor is selected.

There are several rules of thumb in popular use that arrive at recoverable reserves from a consideration of reservoir type, permeability, oil viscosity, gas-oil ratio, interstitial water saturation, type and amount of porosity. Two found to be easily applied are as follows:[20]

• Depletion Mechanism (Solution Gas Drive). For this type mechanism, recoverable reserves will range from as low as 3 barrels per acre foot per percent of pore space in fractured limestone or highly cemented sandstone containing high-solution gas-oil ratio oil (e.g. Spraberry), to 15 barrels per acre foot per percent of pore space in intergranular limestones or unconsolidated sands containing medium-solution gas-oil ratio, low-viscosity oil and high interstitial water. Average value: 10 barrels per acre foot per percent porosity.

• Water Drive (Sands or Sandstones only). Reserves will vary from 5 barrels per acre foot per percent of porosity in low permeability sands containing viscous oils, to 35 barrels per acre foot per percent of pore space in highly permeable sands containing low-viscosity oil and low interstitial water. Average value: 20 barrels per acre foot per percent of porosity.

PRODUCING THICKNESS (h)

Since this is a volumetric determination, an accurate thickness of the reservoir formation must be found. It is necessary not only to know how to read tops and bottoms on various logs but also to be able to recognize tight streaks (low porosity and non-contributory) and subtract their thickness from the gross. The presence of a gas cap and an oil/water contact must be detected so the volume of reservoir occupied by gas and water can be deducted.

1. Tops and bottoms are found as follows:

• *Radioactivity logs.* The gamma ray is excellent for locating tops and bottoms in sands and limes bounded by shales. Shale has high radioactivity, and sands and limes relatively low activity. The mid-point between the high and low is taken as the contact. It must be kept in mind that the gamma ray records through any or no well fluid and through casing or in open hole. Cased-off sands may be surveyed for thickness with this tool.

In areas containing radioactive sands, the neutron is best. It measures hydrogen saturation (which is practically the same as fluid saturation) and is relatively unaffected by abnormally high, natural radioactivity. Because shales contain a large amount of water of crystallization and hydration, they exhibit a low neutron deflection. Sands and limes exhibit higher neutron deflection even though fluid-filled (with filtrate) in the zone of investigation.

• *Self-Potential.* Under most conditions the self-potential curve of the electrical survey gives good tops and bottoms. This curve records the electrochemical and streaming potential in the bore hole. The difference in salt concentration of the interstitial water and mud fluid sets up electric currents which move from the porous rock into the borehole in an effort to restore chemical and electrical equilibrium. This current is measured. The point of slope reversal on the SP curve can be taken as the point of contact between shale and sand. In salt muds approaching the salinity of interstitial water, the SP becomes very small and undependable. It then is necessary to resort to the radioactivity survey.

• *Cores.* Cores can be used if 100 percent recovered. Tops and bottoms also may be found by bit cuttings if other means are not available.

2. Effective pay is that portion of the formation that is contributory. The existence of impermeable and low-porosity streaks must be detected and deducted. Current methods employed are as follows:

• The neutron is easily capable of detecting tight streaks under any fluid condition, inside or outside of casing. It is able to do so since fluid saturation in the tight streak naturally is much lower than in the porous rock. Therefore, its neutron intensity will be much higher. This is true in the case of a lime-cemented sand or a tight, nonporous section in limestone.

• In sandstone, low porosity due to shale content is eliminated easily from effective pay by the gamma ray.

• On original completion, a contact-type log is helpful in picking the porous section.

• On the SP curve, an "eyeball" interpretation can be applied to eliminate those shale-bearing sands that are rendered ineffective due to shale content.

Under conditions of thin, interbedded sands and shales, the area under the SP curve is planimetered and expressed as foot-millivolts.[21] This is divided by the total e.m.f. or maximum millivolt deflection to give a total thickness of sand. The formula is:

$$h = \frac{\text{Area under the SP Log}}{\text{Total e.m.f.}}$$

This gives effective sand thickness in feet.

• Cores, if recovered 100 percent, are helpful in eliminating tight and shaly sections. Analysis of core samples will give porosity and permeability that readily indicate whether the entire section is pay. Cuttings, where properly caught, examined and described will help eliminate non-contributory sections.

3. Oil-water and gas-oil contacts.

• Radioactivity logs, in some select areas, have been found to indicate oil-water contacts.[22] These are in the Texas and Louisiana Gulf Coast Miocene sands of consistent porosity and permeability. The reason for this success is thought to be due to the difference in hydrogen concentration above

and below the contact since the neutron measures this phenomenon.

A small amount of residual oil always remains in the invaded zone of the oil section. This will introduce a slightly different hydrogen concentration if the concentration of hydrogen in the oil differs from that of the filtrate. Gas zones in sand reservoirs are recognizable on the neutron as high intensities. Oil and water zones are relatively lower.[22] Residual gas saturation in the invaded zone is responsible for the contrast.

- It is almost impossible to denote a gas/oil contact by resistivity measurements since interstitial water saturation in the oil and gas zones shows little contrast. Resistivity curves are excellent however, for finding oil/water or gas/water contacts. Water saturation, in this case, is most indicative of the contact.

- Cores and cuttings greatly add to the information necessary to pin down oil/water contacts. The residual oil saturation of core samples is determined in the laboratory. In addition, the transition zone can be defined accurately.

- Where a gas/oil contact is involved, residual oil saturation also will indicate the contact. Bit cuttings, though fairly well flushed, oftentimes will sufficiently reveal residual oil saturation to locate both gas/oil and oil/water contacts. With thickness information at hand, an isopachous map is prepared. For purposes of nomograph, the average producing thickness under the property is determined and placed in the nomograph for solution.

ACREAGE (A)

Productive acreage is determined from a geological structure map.

Under existing proration regulations, the producing life of the property can be determined if the total recoverable oil is known. The annual income, using present market price of oil less the operating cost, taxes and royalty, is annual net income. Total net income can be computed easily by adding income and salvage value of equipment at the end of the producing life of the property.

This represents a certain income over a specific period of time. Using present appraisal methods, a present market value can be given it. It is equivalent to a percentage of the amount of money borrowed today at a given rate of interest and paid back at a rate equivalent to the annual net income of the property.

For example, a property will produce net income of $6,666.66 annually, or $100,000 in the next 15 years (salvage not considered). Using 5 percent interest compounded semi-annually, $69,192 is the discounted value of the future oil production.

For the risk involved in this type of investment and possible chances for error in the computations, the discounted value is further reduced. In popular use at this time is "60 percent of 5 percent discounted value." This would further reduce the appraisal of the property to $41,515. Thus, an oil production investment of $41,515 should return $100,000 in the next 15 years at the rate of $6,666.66 yearly. Published compounded interest tables are used in this computation.

Bear in mind that this is merely the appraisal of the property based on an engineering study. Present market value is the amount of money a willing buyer is disposed to pay a willing seller for a piece of property. The engineering appraisal merely provides a starting point for negotiations. The tax position of buyer and seller should be considered. Properties have been sold for low values in order for the seller to take a capital gain which would be more economical than paying taxes on the production income. These conditions might be changed by altering our tax structure.

To summarize, in determining the amount of oil recoverable from a producible reservoir, determine the storage capacity of the reservoir in barrels per acre foot. This should be corrected for the presence of interstitial water. Shrinkage and the recovery factor must be considered to determine recoverable barrels of stock tank oil per acre foot. By knowing the productive acreage and average effective sand thickness, recoverable barrels of oil can be determined.

The producing life of the property in years may be determined if the allowable under proration rules is known. At the present price of oil, the annual gross income can be calculated. By deducting taxes, operating cost and royalty, net income is calculated. In this manner, the useful life of the property and its earning capacity are determined. On the basis of this knowledge, a present value can be placed on the future net income.

About the Author

Dan H. McLendon received a B.S. degree in geological engineering from Texas A&M College in 1939. He joined Lane Wells in 1940. He served in the armed forces from May, 1941, to September, 1945. Following military service he rejoined Lane Wells and is presently division sales engineer in Dallas.

ACKNOWLEDGMENT

The many helpful suggestions of Warren Jackson, Dallas consultant now deceased, are hereby acknowledged.

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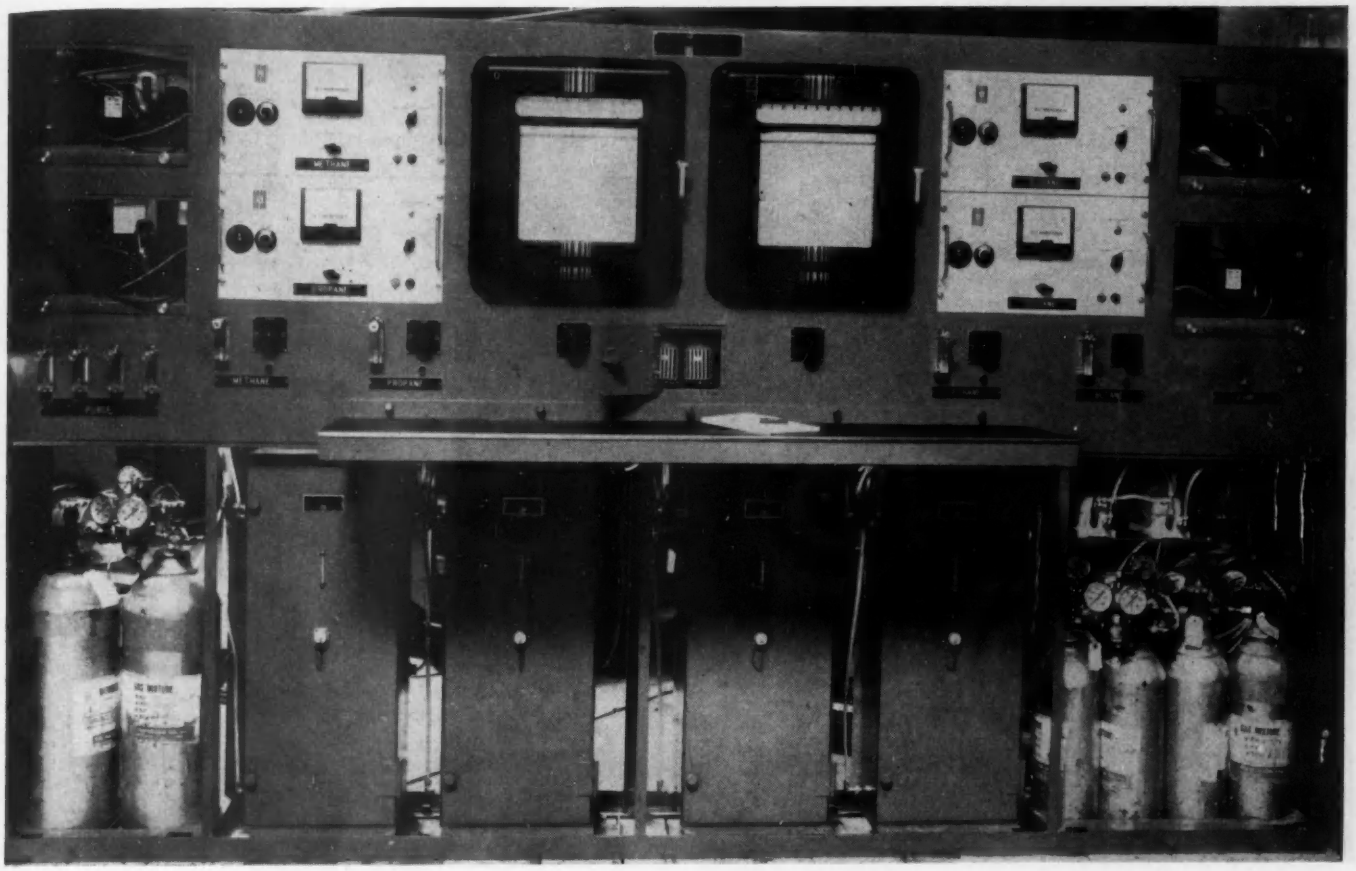


Instrument panel for four-cell infra-red gas analysis. The cover plates on the voltage regulators and the base have been removed. Each control panel is labeled clearly for the particular component it tests.

Improved logging methods reveal productive zones

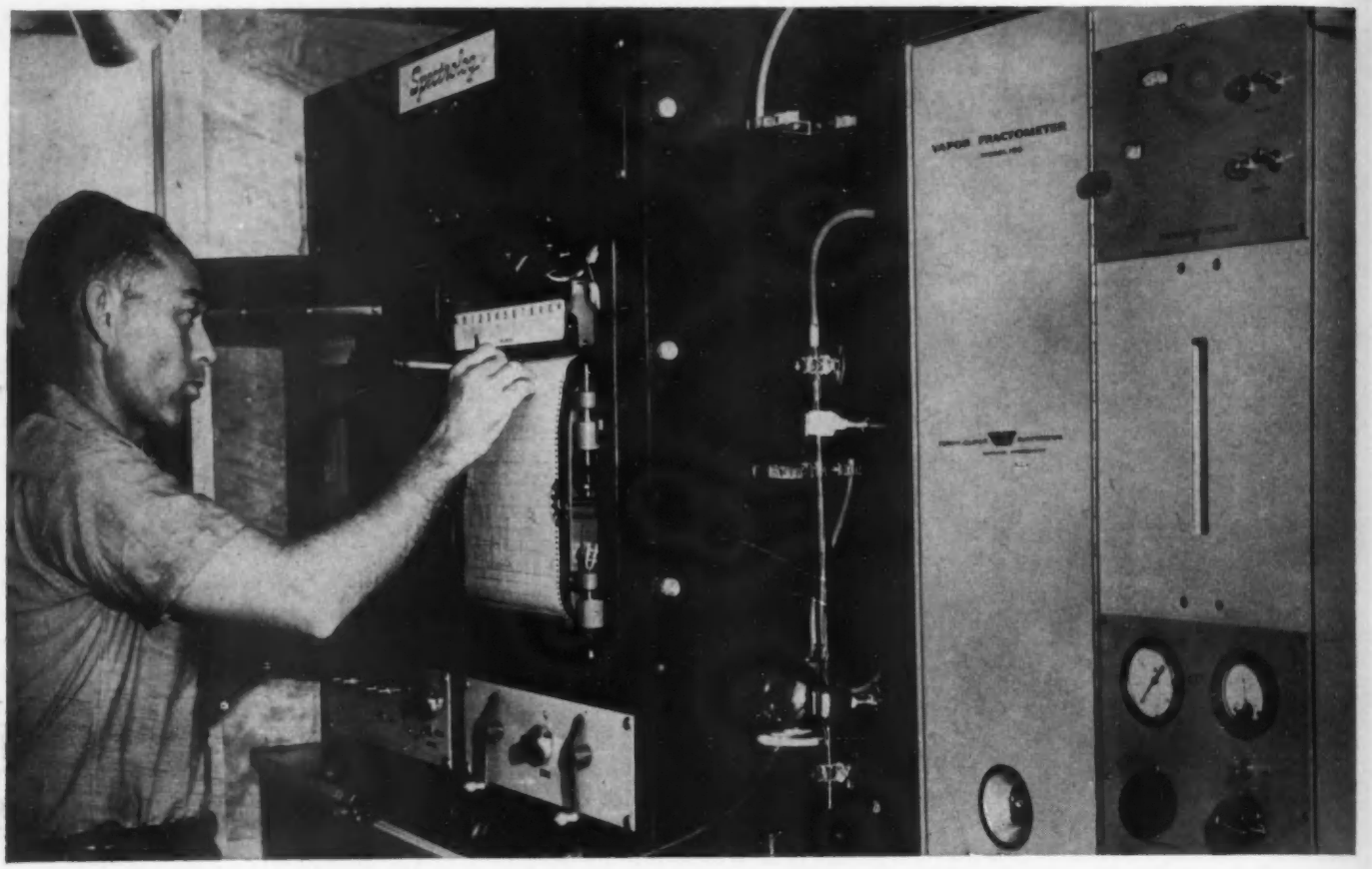
Equipment developed in mud logging can detect shows that once would have been missed

By Karl H. Schmidt, President
Petroleum Service and Research Corporation
San Antonio, Texas

SPECTOGRAPHIC WELL logging has developed new instrumentation for mud logging. The current equipment used to detect and measure hydrocarbons includes infra-red analyzers, mass spectrometers, and gas chromatographs. These tools provide both qualitative and quantitative data. Their sensitivity and reliability preclude the likelihood of penetrating a productive horizon without evidence of hydrocarbons. The quality of the data allows the design of a controlled fluid flow system. The flow system in combination with spectrographically identified and measured hydrocarbons can then be described as a positive formation evaluation tool.

The recognition of productive horizons as they are penetrated, or subsequent to penetration, is an important problem subject to several methods of approach. Logging the mud stream or cuttings returns for direct evidence of hydrocarbons, termed mud-logging, was introduced 20 years ago. This method of mud logging is used to justify coring or testing. It remains an aid in the discovery of new gas and oil reserves. Its inherent limitations required the development and use of new instrumentation and a flow system providing qualitative and quantitative data.

The detection of "shows" is dependent on the penetration of a formation capable of producing gas or oil and that some portion of the in-place hydrocarbon will be released to the return mud-stream. Suitable apparatus is used to extract hydrocarbon gases from the mud and to ascertain the quantity of the hydrocarbons in an air mixture.



Here a gas sample is being analyzed on location. Shown are the infra-red cell units with gas chromatography.

In hot-wire measurement, the hydrocarbon-air mixture is passed over an incandescent platinum filament which ignites the combustible mixture. Heat is developed in proportion to the quantity of combustible material present. Thus, temperature and resistivity of the filament changes. With the filament as a part of a simple wheatstone bridge circuit, shows become detectable and can be measured.

Certain limitations of the "hot-wire" must be considered. The response of the detection circuit is to combustible gases; hence there is no specific differentiation between hydrocarbons and other combustible gases. The method is not qualitative in the sense that the presence of hydrocarbons is definitely established.

The combustibility requirement places another limitation on the method as to the range of concentrations that can be detected. In a direct flow system, the upper limit of hydrocarbon concentration which is measurable is less than 10 percent by volume. Above the operational explosive mixture value, there is insufficient oxygen to support combustion. This limitation could be overcome by the use of a split stream with two or more filament circuits and measured air dilution.

Another inherent limitation is the usable sensitivity of the apparatus which is between 200 and 500 parts per million of hydrocarbons in air. Sensitivity limitations are important when penetration rates are very slow, as in hard rock formation or deep wells in the recent sediments. The hot-wire method has been used successfully where operating conditions provide shows in the range of 1 to 7 percent. Its usefulness is directed to the category of supporting evidence with little basis as a means for predicting the occurrence of producible hydrocarbons. The advantages of this method lie in the simplicity of the apparatus and the economy of its operation.

Improved methods of logging directly for hydrocarbons was brought about by the burden of data interpretation where shows were encountered, and by the cases where productive reservoirs were penetrated without shows. It is widely recognized that no-show but productive horizons occur in hot-wire logging. Many operators have discontinued the use of a good tool because of cases where hydrocarbon evidence was not recorded.

The usual explanation for lack of show is that flushing, of the in-place hydrocarbons, ahead of the bit was so severe that mud and cuttings gas concentration are below the detectibility limits of the apparatus. Current knowledge of reservoirs of the high permeability type indicate they provide excess quantities of gas. Concentrations are actually above the single stream combustible limit.

Qualitative conditions required identification of the individual constituent hydrocarbons, such as methane, ethane, propane and butanes.

Infra-red cells are used in measurement

Quantitative conditions required the measurement of these constituents with an accuracy of 1 percent of the quantity present. The problem of instrumentation involved usability and reliability under field conditions in combination with economic factors. All conditions and requirements suggested the spectrographic field with particular reference to infra-red and mass spectrometry, and gas chromatography.

Infra-red spectrometry. Infra-red gas analysis is based upon absorption of infra-red energy by the hydrocarbons in amounts proportional to the quantity of the hydrocarbons present. Resolution for a single component such as methane is accomplished by using a narrow portion of the infra-red frequency band, where methane is the principal absorber. Other contributing absorbers in the same frequency band are excluded by the use of comparison cells filled with partial pressures of the interfering gases. Cells may be sensitized for ethane, propane or butanes.

Infra-red equipment is capable of both qualitative and quantitative gas measurements with a usable sensitivity of better than 50 ppm. Measurements range from detection sensitivity in a dilute gas-air mixture to 100 percent pure gas. Infra-red is particularly useful for continuous monitoring of a gas stream. Individual cells are being employed for each component to provide continuous recorded evidence of the gases derived from the mud stream and cuttings return.

Mass spectrometry. Mass spectrometry developments have placed this instrumentation within the physical size and economic scope for use in well logging. One instrument is based upon the ionization of gases by a stream of electrons derived from a hot filament. The ionized gas particles exist under high vacuum in an electrostatic field. When subjected to the voltage of a second field, the ionized particles are moved towards a collector.

The path of the moving particle is dependent upon its mass and the accelerating voltage. A particular voltage controls the mass of the particle being collected. A potential results as the charged particles hit the collector plate. The magnitude of the potential is dependent on the quantity of the particles present.

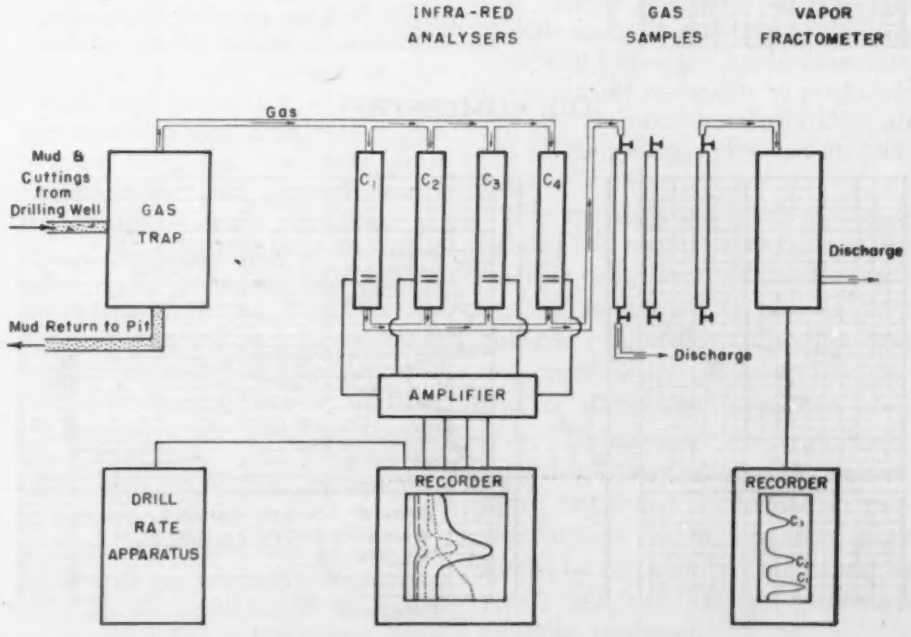
The mass spectrometer proved to be an excellent analytical tool for gas sample analysis, particularly as a scanning type instrument. When used in this manner, samples must be collected for complete analysis. The use of peak selectors and improvements in time required to observe mass peak values provide its potential for use as a stream monitoring instrument. Current application is dependent upon the use to which data is to be applied.

When using mass values to arrive at the volumetric percentages of component hydrocarbons, in a multiple hydrocarbon-air mixture, several mass peak values must be observed. Component determinations involve the solution of simple but tedious simultaneous equations. Each mass peak includes contributions from several components since each constituent divides into numerous mass values by ionization. The mass spectrometer is capable of the continuous monitoring of a gas stream. True quantitative relationships between components is difficult to obtain in this manner.

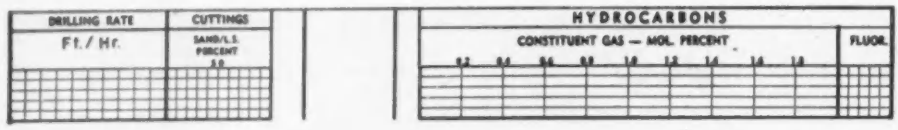
Methane can be more readily determined during continuous flow than other components. It is subject to correction for oxygen or other hydrocarbons dependent upon the mass peak observed. Relationships between undifferentiated mass peaks and the type of hydrocarbon present may be possible and could then serve the purpose of delineation between these fluids. Sensitivity of the instrumentation meets logging requirements for pure component hydrocarbons and falls in the range of 20 to 150 ppm for the various constituents. Constituent concentrations contributing to mass peaks scanned amount to between 20 and 90 percent to the amount present.

Advantages of this equipment lie in its category as a basic standard analytical tool. Its disadvantages are its relative complexities, difficulty in maintaining continuous field operation, and required computational procedures when component values are to be obtained.

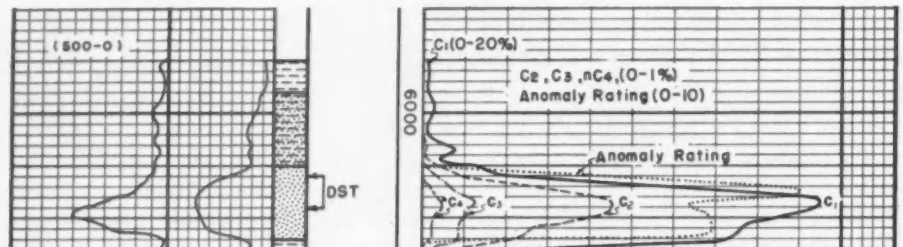
Gas chromatography. Gas chromatography equipment—as currently available—provides an extremely sensitive and accurate means of determining component hydrocarbons in a multiple component-air mixture. The principle of operation for this equipment is based upon the ability of certain materials, to absorb hydrocarbon components and release them



Here's schematic flow and analysis system for spectrographic well logging.



LEAN GAS—CONDENSATE COMPLETION



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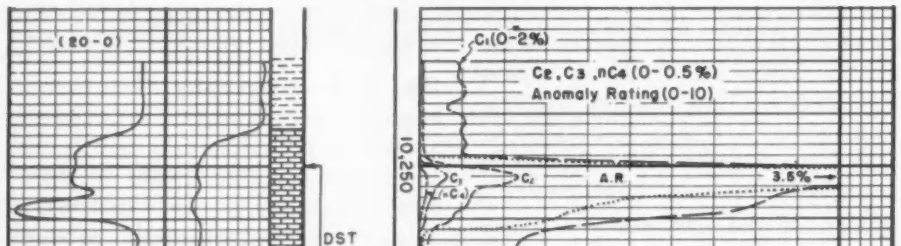
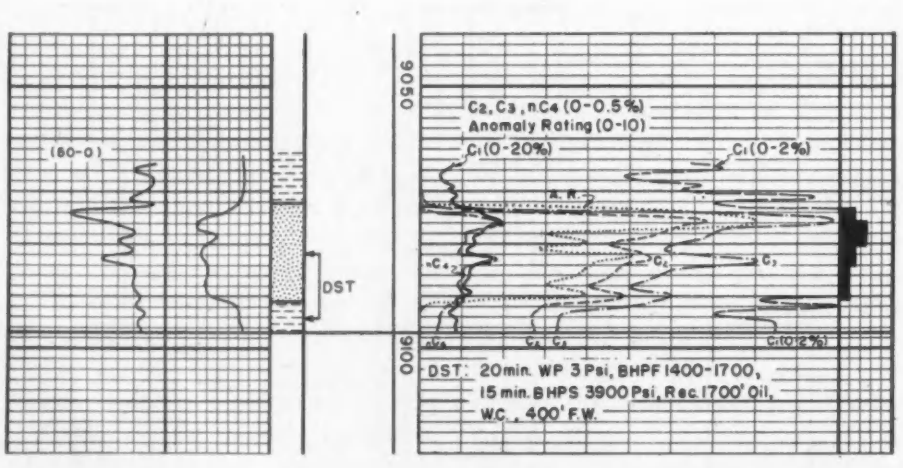


OIL COMPLETION



These gas curves were developed from infra-red and gas chromatography records of wildcat discoveries.

in a time sequence as individual constituents.

The time function serves to identify the components, and by use of thermistors, the quantity of the component present is readily determined. In practice, columns employ suitable packing material through which a constant flow of helium is effected. One to five milliliters of the mixture to be analyzed is introduced to the carrier helium stream, and the analysis is performed and recorded. Sensitivities are very high, ranging between 2 and 10 ppm for the constituents of interest, with good resolution between various gases.

That constituent peaks are related to only one gas with no contributions from other components is of particular interest in this instrumentation. This equipment is primarily for spot sample analysis and is not readily used for continuous monitoring of a stream. Its advantages lie in its simplicity, reliability, extreme sensitivity, and resolution of individual hydrocarbon constituents.

Logging considerations. The research groups of the operating companies generally agree that by using spectrographic equipment of the type described, measurements of component hydrocarbons—methane through butanes of the paraffin series—can be determined to the degree of accuracy stated. The capabilities of this instrumentation are such that analysis is independent of the quantity of hydrocarbons present, which precludes the lack of show for high concentrations.

The problem is a formation capable of producing gas, gas-condensate, oil or water involving two factors. The first deals with the degree to which available pore space is saturated with hydrocarbons; the second, sufficient permeability to allow a commercially productive rate. Other than the differentiation between very low and little permeability, recorded gas anomalies are not currently considered to be a function of the permeability parameter. The data obtained may be used to determine whether the producible fluid will be a hydrocarbon rather than water, if flow occurs.

Gas composition. The solution of the saturation problem is subject to various approaches. Considerable time and effort has been directed towards the meaning of composition, including gases other than hydrocar-

bons. The claim has been made that gases derived from shales and water sands are very dry and contain methane with little or no heavier hydrocarbon constituents. This infers that all dry-gases are derived from shales or water productive horizons. Gas classification from these sources may well be of the dry type, but the inference is erroneous.

Commercially productive reservoirs exist which produce extremely dry gas. One is known to include only methane and ethane, with methane being in excess of 98 percent. Gases derived from shales have been proven to include the complete range from the very driest to the richest gas, typical of that derived from heavy oils with very low solution gas-oil ratios. The conclusion can be drawn, from the varying shale gas compositions, that the horizons from which they are derived are source beds or the outer edge of a productive reservoir.

Relative hydrocarbon component values are not adequate indexes to the producing capabilities of a formation. Also within the realm of composition is the analytical effort directed towards the search for trace gases, other than a hydrocarbon, which may be associated with hydrocarbons derived from water sands, or gases that may be associated with gas or oil sands, but not with water sands. Gas shows are observed as some water sands are penetrated. This occurs with water soluble hydrocarbons or when the formation is partially saturated with hydrocarbons.

In cases of this type, flushing in advance of the bit is reduced, and show magnitudes may be quite large when the rate of penetration is high. To date, no trace gas known to the writer has been observed which meets the interpretation requirement. But this approach is of considerable interest and will undoubtedly be pursued as a research project by many laboratories.

Composition is important in solving the degree of saturation problem. It reveals the type of hydrocarbon, gas, gas-condensate or oil present in the formation. Classification as to type is effected through the relative values of constituent hydrocarbons. If only methane and ethane are present as the constituents of a show, obviously only gas could be the saturating fluid.

Oil is the saturating fluid when butanes and pentanes are present in proportionately high quantities. All other conditions being equal, magnitude of anomalies are greater for gas sands than for oil sands.

Gas anomaly magnitude. A method currently used as a basis of interpretation may be described as anomaly rating. Through the use of certain assumptions, further extrapolation to compute hydrocarbon saturation, in terms of pore space percentage, is possible. The magnitude of an observed gas anomaly in this theory is related to the degree of formation saturation. Several factors are involved, such as the type of hydrocarbon saturation, gas or oil, rate of penetration, mud flow volumes, mud characteristics, gas trap efficiencies, and other flow stream conditions.

If a percentage saturation computation is to be made, two physical characteristics of the formation are involved. These characteristics are the formation porosity and the degree of formation flushing by the drilling mud ahead of the bit. The porosity assumption is not critical. Values are obtainable with reasonable accuracy by inspection of cuttings.

Assumed porosity may be in error by several percent without material error in the computed saturation value, particularly in the higher porosity range. Flushing ahead of the bit is a critical factor with specific values for permeable formations having a material effect upon computed hydrocarbon saturation. This factor is probably the least known parameter in logging; however, it can be categorically placed relative to value by experience gained in other reservoir engineering fields. As more reservoirs are developed for which controlled logging data is available, experimental values for flushing or a combination of flushing and up-hole dispersion will become available.

Flushing in advance of the bit is placed in two categories related to permeability or reservoir flow capacity. If a formation has sufficient permeability and porosity to allow microlog separation, flushing is considered to be 80 percent or more. When porosity is low and permeability is noneffective—probably less than one millidarcy for hydrated material—flushing is considered to be 30 percent or less.

Spectrologging results. Experience in the logging of more than 100 wells has shown, when empirical anomaly rating or computed saturation is employed, the existence of commercially productive hydrocarbons can be recognized. This can be done through the use of spectrographic data related to drilling conditions. The original aims of this new logging technique can be considered proven if predictions of gas, gas-condensate or oil in wildcat wells prior to any testing can be designated as discoveries. The type of fluid saturation can be recognized. Highly permeable sands provide large gas anomalies, and hydrocarbon saturation free of producible water can be predicted. This has been demonstrated independent of the geologic province or drilling conditions.

The spectrographic method of well logging has become a recognized aid in the delineation of hydrocarbon bearing formation. It can be used either in conjunction with other data or to provide an independent evaluation of potentially productive horizons. The logging process, with its improved instrumentation and interpretative technique, is designed to provide answers as to whether pipe should be set, what footage should be tested, and will gas, gas-condensate or oil be produced.

—The End

About the Author

Karl H. Schmidt, president and general manager of Petroleum Service and Research Corporation, was graduated from the Colorado School of Mines in 1936, with a degree in geological engineering (major in geophysics - meritorious award). He formerly was with American Askania Corporation, Arkansas Fuel Oil Corporation, G. E. Kadane & Sons and the Oil and Gas Division of the Bureau of Mines. He founded Petroleum Service Company in 1945, later incorporated as Petroleum Service and Research Corporation in 1954. He is a member of the AIMME, API, AAPG, SEG and a registered professional engineer.

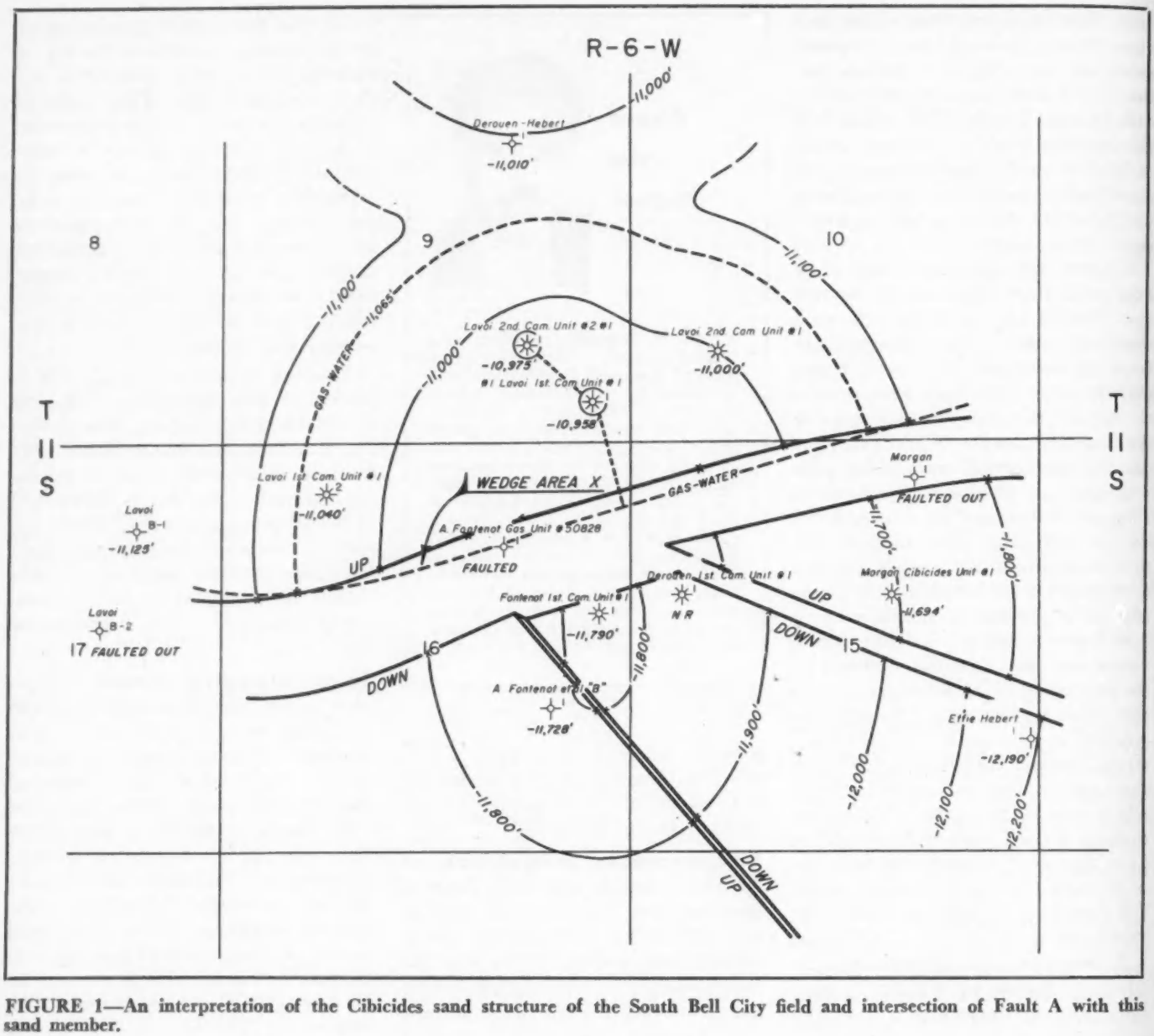


FIGURE 1—An interpretation of the Cibicides sand structure of the South Bell City field and intersection of Fault A with this sand member.

A case history

Wedging does make a difference

Fault wedging is important in calculating reservoir volumes

By Don Whitaker, Geological Supervisor
Texas Gas Transmission Co., Houston

THE SAND WEDGE lying against a fault plane often is ignored due to its relative insignificance when making sand isopachs. Any attempt at isopaching this wedge area becomes meaningless in dealing with thin sands and average dipping fault planes. As the thickness of the sands encountered increases, the wedge volume gains significance as a part of the reservoir; however, it seldom reaches the point of requiring detailed map-

ping to determine its volume relative to total reservoir volume.

There are a number of ways to account for these wedge volumes without detailed isopaching. They involve the placing of the fault trace so that part of the wedge is included in the isopach. These methods are in common use today and, in most instances, reach the same degree of accuracy as detailed isopachs.

In South Bell City field, Calcasieu Parish, Louisiana, a case where a wedge (Figure 4) is of sufficient volume to warrant detailed isopaching to reach an accurate and equitable account of the total reservoir. In doing reserve calculations, accuracy is limited by so many variables that an area of this consequence demands more attention than a rough estimate. The mechanics involved in arriving at an isopached wedge are in common practice by geologists today, especially those conducting evaluation studies.

Figure 1 is an interpretation of the Cibicides sand structure in this field. A gas-water contact that follows its depth counterpart around the northern end of the structure is plotted on the map and a gas-water contact that follows its depth counterpart paralleling the (A) fault plane contours (from Figure 2). The northern arcuate fault trace a fault (A) and the gas-water contact lying against the fault plane form the limits of the fault wedge in question. The lower part of the Cibicides sand is present in the A. Fontenot well but falls below the water table.

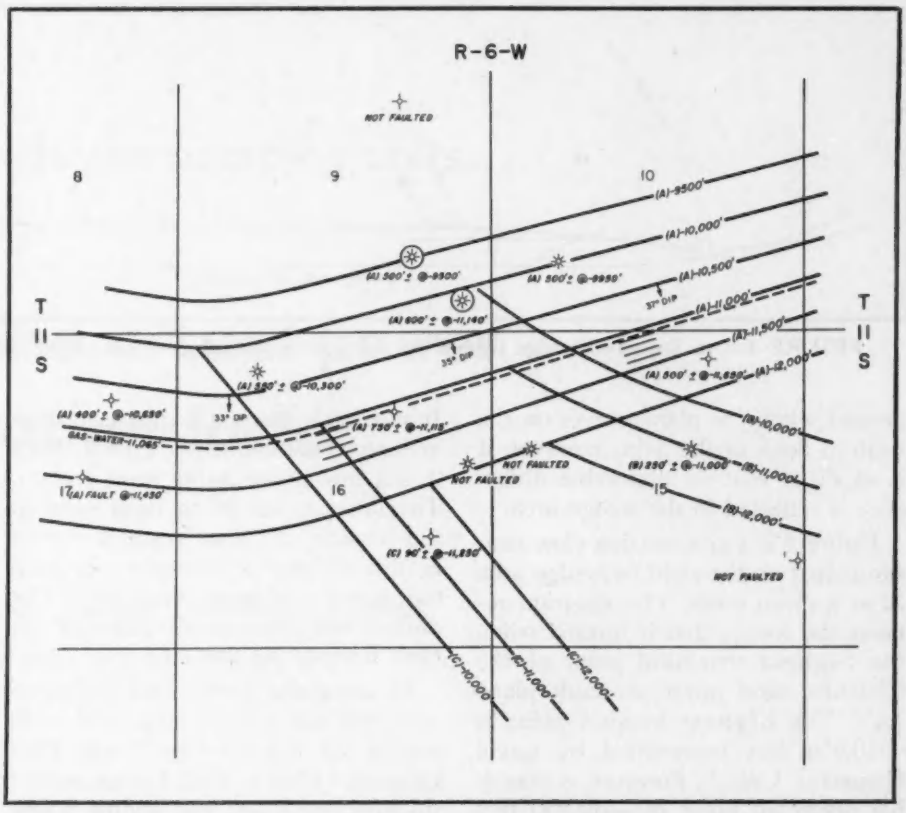


FIGURE 2—The intersection of fault planes A, B and C showing how they indirectly affect the wedge area.

Faults A, B, and C are represented by a fault plane map in Figure 2. Contours on all fault planes were shown as they indirectly affect wedge area X by being a part of the over-all structure. The gas-water contact lying against fault plane (A) is plotted here and then transferred to Figure 1. There is a slight flattening of dip evi-

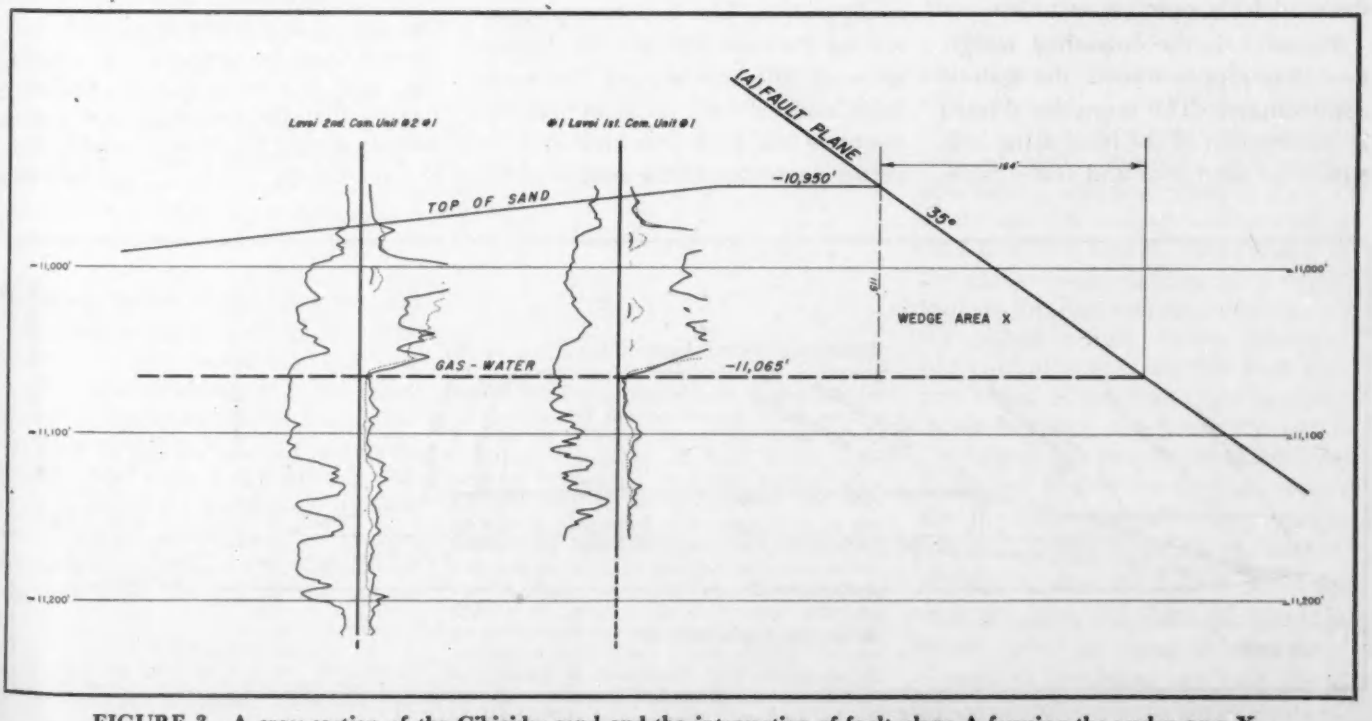


FIGURE 3—A cross-section of the Cibicides sand and the intersection of fault plane A forming the wedge area X.

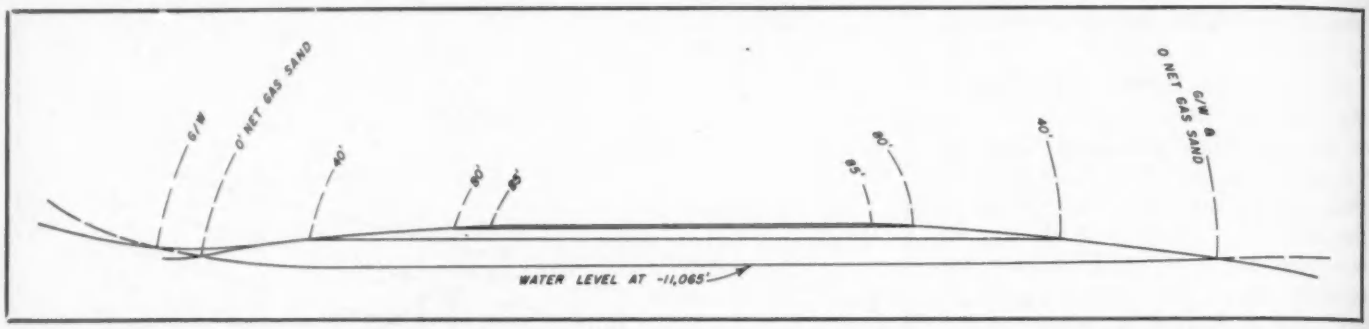


FIGURE 4—An isopached wedge formed by the intersection of the fault plane with structural sand tops and water table.

denced when the plane curves on the western flank of the field; however, it is so slight that no noticeable difference is reflected in the wedge area.

Figure 3 is a cross-section view consummated on the right by wedge area X at a given point. This diagram reflects the wedge that is formed when the highest structural point of the Cibicides sand intercepts fault plane (A). The highest known point is —10,958 feet represented by Lavoi Camerina Unit 1; however, a plausible predicted point of —10,950 feet was used. Moving off the peak of the structure and on to the flanks, the wedge begins diminishing toward the points of intersection of gas-water contact and fault A's northern arcuate trace.

As seen on this section, neither these nor any of the other wells are in a position to be completely above water. For this reason, a total net sand isopach was not prepared. The wedge area would increase if more of the sand body were above water.

Figure 4 is the isopached wedge. For clearer presentation, the scale is approximated. The limits are formed by intersection of the fault plane with structural sand tops and water table. Immediately below the gross sand top in Lavoi First Camerina Unit 1, Well 2 is a low permeability sand section. To eliminate including tight sand in the isopach, the fault trace is curved in this vicinity to intersect net sand top instead of gross sand top. The dashed line indicates the trace of the fault intersecting net sand top.

In using the predicted point of —10,950 feet on the structural cross section, it allows the Lavoi First Camerina Unit 1, Well 1 to be moved up structure 8 feet and adding 5 feet of net sand to the isopach along the —10,950-foot contour line. This extra 5 feet is shown by plotting an 85-foot thickness line on the isopach. In the resulting planimetering on the proper scale map, this wedge area represents approximately 5 percent of the total reservoir volume.

Figure 5 is an isometric view of Figure 4 with the vertical scale exaggerated. Right triangle cutting planes are inserted for a clearer picture of configuration. The hypotenuse representing the front flat face, the bottom adjacent side representing the water table, and the back adjacent side representing the back face that remains vertical over the entire length of the wedge even though it curves on either end. The upper points of these triangles are placed in a position to show where the isopach lines become a part of the wedge. Control of the spacings of the 40-foot and 80-foot isopach lines along the front face of the wedge is a result of connecting the extreme end points with a straight line.

The Lavoi First Camerina Unit 1 well would control the spacings in its immediate area; however, it would vary only slightly from the straight line reaction shown. Since this same well controls the complete 85-foot thickness and the structure is assumed flat along that line, it will have to be plotted as a straight line.

In work that depends largely on estimation, this wedge volume may not sound important enough to warrant detailed mapping since the isopach itself is an estimated factor even though based on a semiscientific approach. However, it assumes more significance in relation to a reservoir of this size. If any reservoir or part of a reservoir can be mapped with meaning, and this area can, it logically follows that the semiscientific approach should improve the accuracy of the estimate. —**The End**

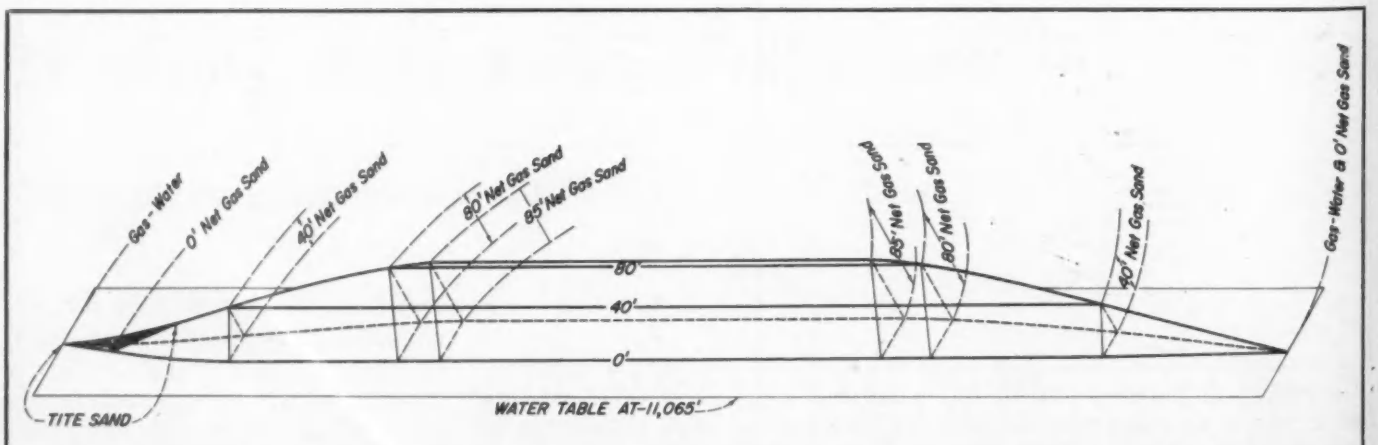


FIGURE 5—An isometric drawing of the wedge area X.

For electric motor-driven pumping units . .

How to determine actual power output and derating factor

Proper considerations can reduce investment costs of pumping unit installations

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ELECTRIC MOTORS driving oil well pumping units cannot deliver an average horsepower output equal to name plate rating without the effective or rms current exceeding rated current. These motors must be derated if they are to operate without overheating. The following procedures determine percent of rated power output that pumping unit electric motors can deliver. This requires a determination of average power output under actual operating conditions. A procedure for determining the average power output and derating factor is developed that only requires measurements which can be made in the field by engineers and field testers.

Pumping load. Reaching general conclusions regarding ratio of peak load to average, motor load carrying capacity and efficiency requires many tests on electric motor driven pumping units (Figures 1, 2, 3, 4). As tests are made on more and more installations, these items are found to vary over a range of values. The greater the number of tests, the better will be established the limits of the ranges and the average values of the items being checked.

ACKNOWLEDGMENT

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Average output and derating factor. Oil producers have procedures for estimating the prime mover output required for sucker rod pumping installations. Engines usually are applied so average power output will be 65 to 70 percent of the maximum brake horsepower at operating speed. Electric motors are applied to develop a power output less than name plate rating to prevent thermal overload. How much less is the question.

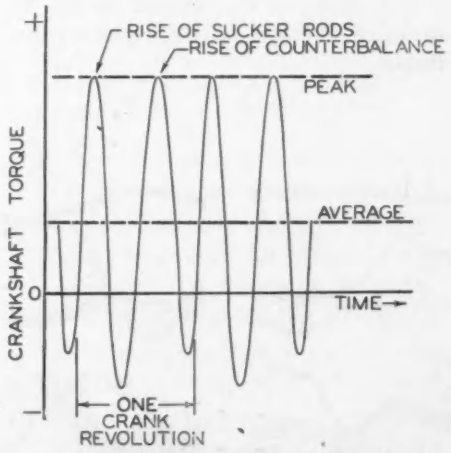

FIGURE 1—The load at the crankshaft of a properly counterbalanced pumping unit is similar to that shown. Actual curves of crankshaft torque versus time are irregular in various ways, but load variation and positions of load limits with respect to average load are typical. The electric load of the motor does not vary as widely compared to average load as the load at the crankshaft. Inertias of rotating parts in the system absorb energy on peaks and release it on valleys. The result is that peak motor electric torque referred to crankshaft is less than peak torque at the crankshaft. Peak motor electric torque is referred to crankshaft by multiplying it by the ratio of motor speed to crankshaft speed.

When a motor drives a pumping unit, the oil producer needs to know what percent of rated power output a given type of motor can develop without being thermally overloaded. Proceeding, derating factor is defined as the ratio of average motor output on a pumping load to the output that the motor would develop on a steady load at the rms current measured on the pumping load. When measured rms current is near the full load current rating of the motor, the derating factor becomes the factor by which the motor power rating should be multiplied to give the average output that the motor can deliver on a pumping load without being overheated. Obviously, derating factors must be obtained from field tests of electric motor driven pumping units.

Tests to determine the load carrying capacity of motors driving pump-

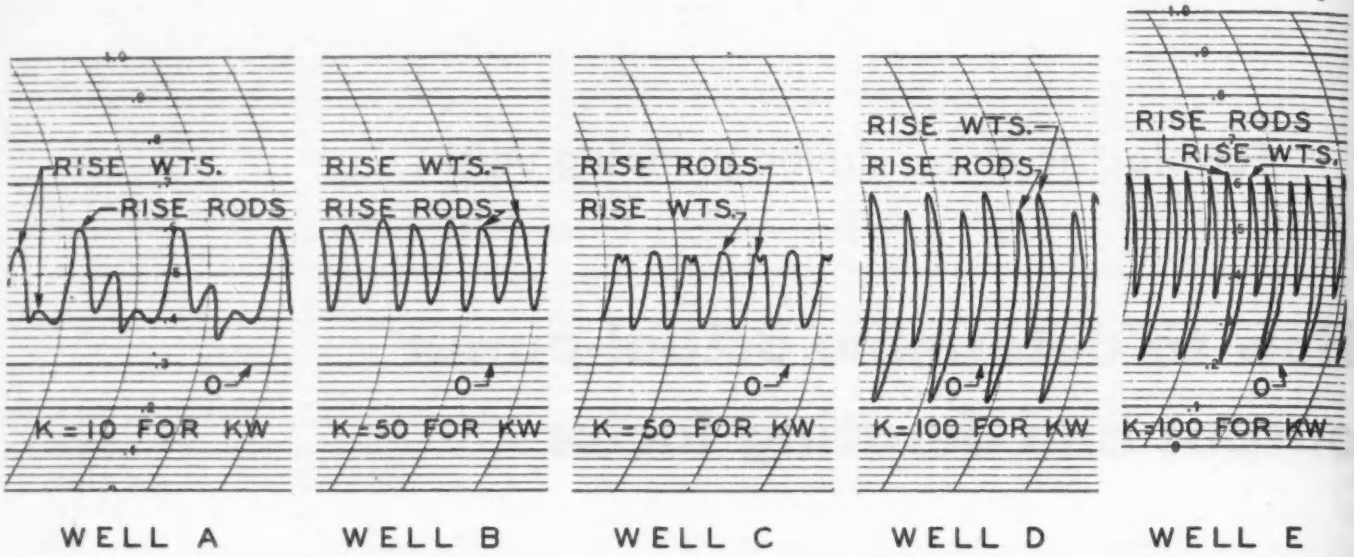

FIGURE 2—The load versus time relationship is influenced by many factors and is different for each installation. This figure shows recording wattmeter records for a number of different wells. These are not accurate records of load versus time but they show that there are differences in load characteristics. The ratio of peak load to average load varies from a maximum of 4 to 1 to a minimum of 1.8 to 1. The highest peak to average ratios are found where the induction motor driving the pumping unit momentarily becomes an induction generator at the top and bottom of the pumping stroke. During these intervals, energy is transferred from the pumping unit through the motor to the power distribution system.

ing units should be taken under conditions where the measured rms current is between 80 to 120 percent of rated current. A 5 to 8 percent slip Design D motor at half load will have a slip equal to that of many high torque, normal slip Design C motors operating at full load. Therefore, Design D motors operating at light loads will behave more like loaded Design C motors and derating factors calculated at light loads will be low.

Derating factor requirement. Obtaining derating factor as defined requires a determination of average motor output under actual operating conditions. Average output cannot be measured directly but it can be found by a method which does not require special instruments or equipment. Briefly, this method is as follows:

1. Connect a watthour meter to measure average power input to the motor.

2. Connect a thermal ammeter to measure rms current.

3. From the performance curves of the motor, determine output and efficiency on a steady load at the rms current measured on the test.

4. Divide steady load output by efficiency to get the input to the motor on a steady load at the measured rms current.

5. Subtract steady load output from

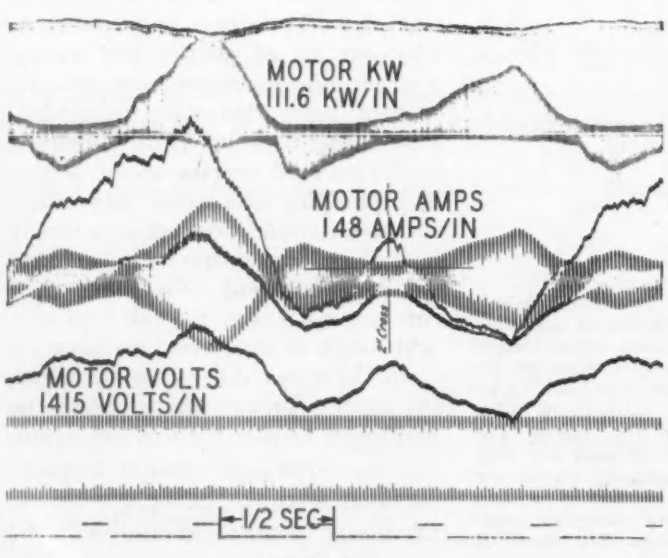

FIGURE 3

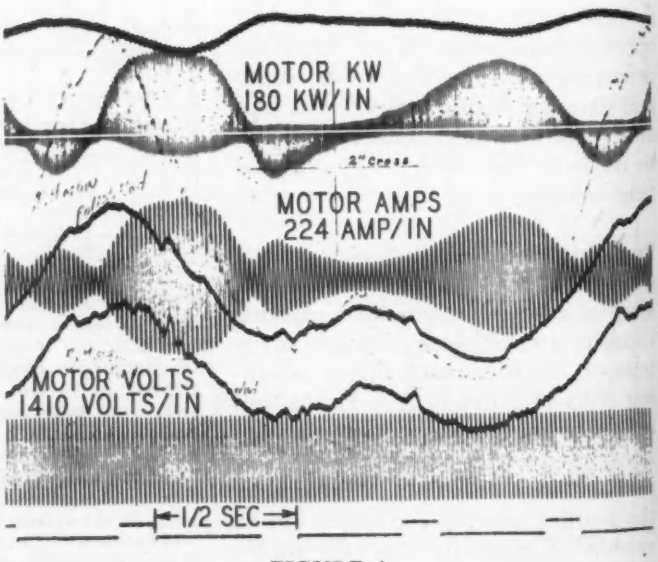

FIGURE 4

Oscillograph records of power, current, and voltage at the input to electric motors driving pumping units are shown in Figures 3 and 4. The oscillograph records of power show that power is delivered at a frequency of 120 cycles per second. The records of current look like textbook examples of amplitude modulated radio waves. Note the rise in current that occurs when the load goes negative after the peaks.

the steady load input to get motor loss.

6. Subtract motor loss from measured power input to get actual average output.

Derating factor is determined by dividing the average output on the test by the output the motor would have developed on a steady load at measured rms current.

The procedure outlined is illustrated by a test where a 60 horsepower, 440 volt, 77 ampere, 1170 rpm, high torque, normal slip, Design C motor was driving a pumping unit 18.6 strokes per minute. The performance curves of this motor are shown in Figure 5.

From measurements on test,

Average motor input = 49.4 hp
RMS current = 84.7 amperes

On a steady load at 84.7 amperes, point (A) Figure 5

Output = 66.7 hp, point (B), Figure 5
Efficiency = 0.92, point (C) Figure 5
Input = 66.7/0.92 = 72.5 hp.
Loss = input — output =
72.5 — 66.7 = 5.8 hp.

On the test,

Average output = measured input — loss
= 49.4 — 5.8 = 43.6 hp
= 43.6/66.7 = 43.6 hp

$$\text{Derating factor} = \frac{\text{Average output on pumping load}}{\text{Output of motor on steady load at rms current measured on pumping load}}$$
$$= 43.6/66.7 = 0.654$$

The example presents data on an installation where a normal slip motor was operating at a current 10 percent above rated, whereas average output was only 73 percent of rated.

Practical use. One practical use of derating factors is to compare the performance of normal slip motors with that of 5 to 8 percent slip motors when driving pumping units. A 60 horsepower, 440 volt, 1125 rpm, 71 ampere, 5 to 8 percent slip, Design D motor was installed in place of the 60 horsepower, normal slip motor for which data is given in the previous example. The performance of the 5 to 8 percent slip motor was as follows when the rate of production was within one percent of the same number of barrels per day:

From measurements taken on test,
Average motor input = 49.4 hp
RMS current = 60.0 amperes

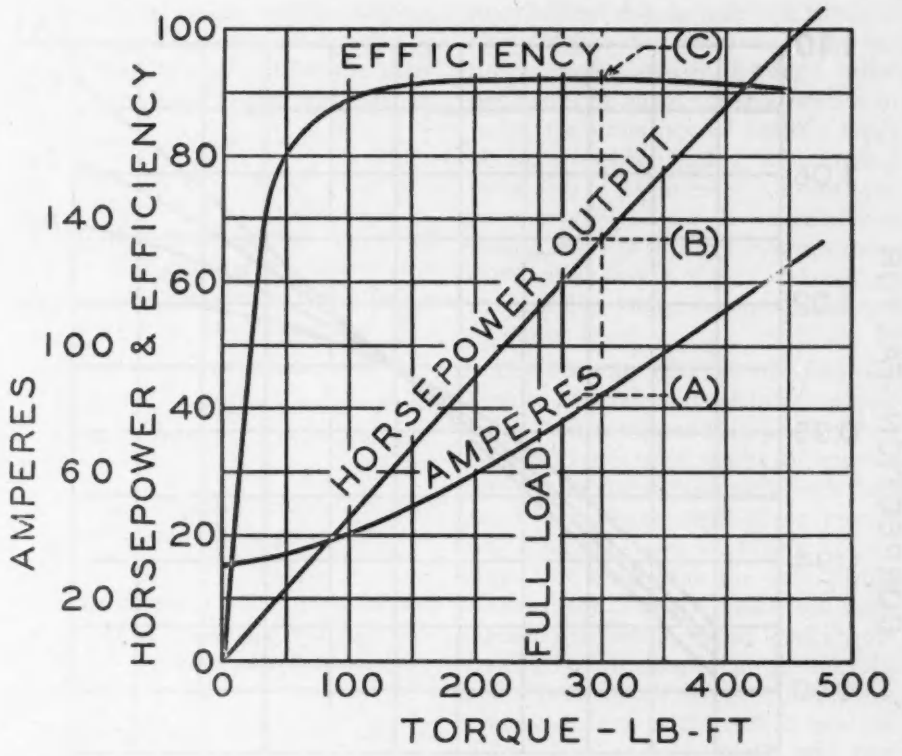

FIGURE 5—Here are performance curves for a 60-horsepower, 440-volt, 77-ampere, 1,170-rpm, high torque, normal slip Design C motor.

On a steady load at 60.0 amperes,

Output = 50.1 hp
Efficiency = 0.896
Input = 55.9 hp
Loss = 55.9 — 50.1 = 5.8 hp

On the test,

Average output = 49.4 — 5.8 = 43.6
Derating factor = 43.6/50.1 = 0.87

This typical example shows that a 5 to 8 percent slip motor is considerably underloaded when replacing an overloaded normal slip motor of the same rating. The results are in agreement with data presented previously which showed that 5 to 8 percent slip motors can develop 30 to 35 percent more average power on a pumping load without being overloaded.[1] In the preceding example, a 50 horsepower 5 to 8 percent slip motor would have been satisfactory while the 60 horsepower normal slip motor was overloaded.

Load variations were less severe than normal on the installation used in the example. This accounts for the derating factors being higher than average. Tests reported in the reference showed average derating factors to be 0.58 for normal slip motors and 0.80 for 5 to 8 percent slip motors where rms currents ranged from 80 to 121 percent of rated.

Voltage was 450 at the terminals of the two 60-horsepower motors for which test data are given. This, along with the measured power input and measured rms current, permitted calculation of power factor. Power factor was 0.79 for the 5 to 8 percent slip motor and 0.56 for the normal slip motor. The higher power factors found with 5 to 8 percent slip motors permit savings in capacitors, distribution lines and transformers.

Accuracy. Error in determining average output by the method outlined, will be less than one percent if terminal voltage is within 7½ percent of rated and if calculated output is greater than 45 percent of rated. For these conditions, accuracy of the method is as good as that of the measurements and furnished performance curves.

Percent error will increase as motors are more lightly loaded and the more operating voltage deviates from rated. Error can be held to one percent or less if core loss is obtained in

FIGURE 6—This set of curves illustrates a factor for correcting motor power output at a given current and rated voltage for deviation in voltage from rated. (A—Power output at given current and rated voltage in percent of rated.) The curves are averages of several motors of different types and sizes. Use of the chart is as follows: (1) From the performance curve of the motor, determine the power output at the current equal to rms current measured on the test. (2) Divide power output determined in step 1 by rated output and multiply by 100 to get output in percent of rated. (3) Divide terminal voltage measured on the test by rated voltage and multiply by 100 to get operating voltage in percent of rated. (4) Enter the chart at the bottom at the correct percent voltage and move upward to the correct percent load by interpolating between the curves for the various loads. (5) Move horizontally to the left to obtain correction factor. (6) Multiply output determined in step 1 by the correction factor to find the output at measured voltage.

addition to the information usually furnished with performance curves. Motor loss includes i^2r loss, friction loss and core loss. Friction is a small part of the total loss and can be considered constant. I^2R loss is determined by rms current which is measured. Core loss is made up of two parts, one due to hysteresis (which varies as the 1.6 power of voltage) and one due to eddy currents (which varies as the square of voltage).

Hysteresis loss usually will be between 3 to 4 times eddy current loss. A close approximation for adjusting core loss for changing voltage is to assume that core loss varies as the 1.75 power of voltage. Therefore, if voltage is 10 percent higher than rated, core loss will be increased to $(1.1^{1.75})$ times core loss at rated voltage.

Whether adjustment of core loss is necessary for desired accuracy in calculated output depends on motor design as well as percent load and deviation of operating voltage from rated. Examination of characteristics of seven motors showed differences in the need for adjusting core loss. Ranges found for minimum values of average power output to hold error in calculated output below 1 percent without correcting core loss are given in Table 1.

TABLE 1

Voltage	Ranges of Minimum Power Outputs For Less Than 1 Percent Error Without Correcting Core Loss
1.125 x rated	0.39 to 0.74 x rated
1.10 x rated	0.31 to 0.59 x rated
1.075 x rated	0.23 to 0.44 x rated
1.05 x rated	0.15 to 0.29 x rated

When required, the procedure for correcting motor loss for deviation of voltage from rated is as follows:

1. From performance curves, determine total motor loss for the rms current measured on the test.

2. Subtract core loss from this total loss to get i^2r and friction loss.

3. Obtain the ratio of measured voltage to rated voltage.

4. Multiply core loss by this ratio raised to the 1.75 power to get core loss at measured voltage.

5. Add adjusted core loss to i^2r and friction loss to get total loss corrected for deviation in voltage.

Calculating derating factors requires determination of the output that the motor would deliver on a steady load at the rms current measured on the test. Motor output at a given current varies to some extent with voltage. This should be taken into consideration if derating factors are to be obtained with the greatest possible accuracy.

The degree of change in motor output at given current with change in voltage depends on the percent load. This is illustrated by Figure 6, which gives correction factors by which power output at rated voltage and a given current should be multiplied to give output at voltages ranging from 90 percent to 110 percent of rated. Characteristics of some particular motors may differ enough from those used to obtain the curves in Figure 6 to justify preparing additional curves that apply specifically to these motors.

Field testing. A thermal ammeter and watthour meter will supply the essential information for calculating motor output and derating factor. A voltmeter will provide measurements needed to make corrections for deviation of operating voltage from rated, and to determine balance of phase voltages. Current peaks and the state of counterbalance of the pumping unit may be obtained with a clamp-on ammeter. Improper counterbalance lowers the derating factor.

The test procedure in the field is as follows:

1. Connect the watthour meter and thermal ammeter.

2. Observe rotations of the disc of the watthour meter at 4 or 5 minute intervals. When this shows that well

conditions have stabilized, measure voltage on all three phases.

3. Obtain the current peak on the rise of rods and the current peak on the rise of weights in all three phases.

4. Time the disc for two or three 2½ to 3 minute intervals to obtain an accurate average disc rpm. Average motor power input is calculated from the following formula:

$$\text{Average hp input} = \frac{\text{disc rpm} \times \text{disc K} \times 60 \times 1.34}{1000}$$

5. Read the thermal ammeter, being sure that the instrument has been carrying motor current for at least 50 minutes. Record the current transformer ratio and the number of conductors passing through the core of the split core transformer (if used) so that the proper scale factor can be determined.

6. If the current peaks on rise of rods and rise of weights are found to be 5 or more percent different, respectively, (in the different phases) it is a good idea to check rms current in a second phase. RMS current in the third phase can then be estimated assuming that rms current varies in the same proportion as the average of the current peaks for the various phases. Over-all average rms current is found by averaging the rms currents for the three phases.

The need for care in taking measurements cannot be over-emphasized. Final measurements should not be taken while well conditions are changing. The disc of the watthour meter should be timed at 4 to 5 minute intervals prior to taking final measurements to be sure that conditions are stabilized. This is necessary to insure under the same pumping conditions. When in doubt, repeat measurements, particularly the timing of the disc of the watthour meter.

Efficiencies. Much more information is needed on efficiencies of pumping units under actual operating conditions. When driven by an electric motor, the efficiency of a pumping unit is determined as follows:

1. Connect a watthour meter and thermal ammeter to measure average input and rms current.
2. Install a polished rod dynamometer to measure well load.
3. Follow the procedure described to insure stable well conditions recognizing that at 50 minutes to an hour is required for the thermal ammeter to give rms current.
4. Measure voltage.
5. Time the disc of the watthour meter for 2½ to 3 minutes. During this time let the stylus of the dynamometer trace the dynamometer card continually for at least one minute.
6. Read the thermal ammeter.
7. Calculate average power output of the motor by the method outlined.
8. Calculate polished rod horsepower from the dynamometer card.
9. Calculate the efficiency of the pumping unit by dividing polished rod horsepower by average motor output.

Pumping unit efficiencies can be plotted against polished rod horsepower in percent of nominal horsepower rating of the speed reducer to establish an average curve of efficiency versus percent load.

The operating efficiency of motors that drive pumping units can be determined by obtaining average power output and dividing by measured power input. Efficiency so determined should not be used to compare normal slip with 5 to 8 percent slip motors since it does not include the effect of motor slip on the behavior of the entire pumping system. Energy input per barrel of liquid lifted is needed to judge the efficiency of various types of motors when applied to pumping units. A 5 to 8 percent slip motor may have a point or two lower efficiency than a normal slip motor when driving a given pumping unit and even so may use less kilowatt-hours per barrel of liquid lifted.

Comparisons of system efficiency require accurate tests of motor power input and corresponding producing rate with the two types of motors when pumping a given well. Such tests must be made on wells where pumping conditions will stabilize. Tests should be made with the same pump size and stroke and at nearly the same strokes per minute. Fluid level should be checked to assure that the net lifts are approximately equal. A noticeable change in net lift when a well is pumped at a given stroke and spm will indicate a change in well conditions or a change in condition of subsurface equipment.

Procedures have been outlined for determining average output, derating factor and power factor of motors that drive pumping units; for obtaining the efficiency of pumping units, and for comparing over-all efficiencies of sucker rod pumping systems when different types of motors are applied to drive the pumping units. Reliable information on these items is scarce. Without reliable information, costs to equip pumping units with electric motors can be higher than they need be.

The first step to obtain needed information is to provide field production offices with a thermal ammeter, a clamp-on ammeter, a voltmeter and watthour meter. These instruments will provide all essential electric measurements. A polished rod dynamometer must be added if test work is to include determination of efficiency of pumping units.

The next step is to train personnel to use the instruments safely and to obtain accurate and reliable data. If such a program were followed, the correct answers would be known in a year or two, and the job of equipping pumping units with electric motors could be accomplished at the lowest possible cost.

About the Author

M. H. Halderson, assistant to the chief production engineer of Phillips Petroleum Company, handles principally the supervision of an Engineering section which handles electrical, analytical and special problems, concerning all phases of oil production. He received a degree in electrical engineering from the University of Nebraska in 1934; in 1936 he obtained his M.S. in physics from the same. He began his 22 years with Phillips as an apprentice engineer in electrical construction. Since that time he has held several positions before being elevated to his present capacity.

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Drilling practices are improved through . . .

New developments in gyp muds

A new chemical material, ferrochrome lignosulfonate, has brought about wider uses of gyp muds

By Robert J. Smith
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WITHIN THE last year, a new type mud additive has brought about changes in drilling mud treatment. This chemical, a ferrochrome lignosulfonate material processed from the sulfite liquor of the paper-pulp industry, is being used extensively for controlling viscosity, gel strengths and filtrate loss in gypsum muds, sea-water muds, lime muds and fresh-water muds. Easier maintenance, closer-to-gage holes, fewer fishing and stuck pipe jobs, and better resistance to contamination are some of the results obtained by using this new mud additive.

When gypsum muds first were introduced in the Williston Basin area, characteristic high gel strengths prevented their use in areas requiring weighted muds. This new chemical, however, permits control of gel strengths and makes gypsum muds applicable over a greater range of drilling conditions[1]. As a result, gypsum muds treated with ferrochrome lignosulfonate are being used widely throughout the U. S. and elsewhere.

These muds have been used successfully on offshore locations using sea-water for make-up water. The cost of transporting fresh water to the rigs increases the drilling mud costs and additional storage space has to be provided. Muds using sea-water eliminate these problems. Lime muds and carboxymethylcellulose-lignite muds have been commonly used on these offshore locations. However, sea-water-lime muds are subject to solidification and gelation at deep drilling temperatures. Carboxymethylcellulose-lignite-sea-water muds require large amounts of dilution to maintain desirable mud properties[2]. The use of ferrochrome lignosulfonate instead of the variety of materials used in other sea-water systems permits easy control of the viscosity, gel strengths and filtrate loss with minimum water dilution.

The following are examples of field usages of this new thinner in gypsum and sea-water muds to solve problems that heretofore were extremely troublesome and expensive.

Drilling the Anahuac shale of Calhoun County, Texas. In recent years, drilling problems associated with the troublesome Anahuac shale of the Texas Gulf Coast have been lessened by the use of muds that inhibit the hydration and swelling of shales. Lime muds have been used extensively because of their inhibiting properties and because of their resistance to contaminants such as cement, gypsum and salt. However, at high bottom hole temperatures, lime muds thickened or gelled excessively. This has been attributed to the fact that caustic soda and lime react with the clay minerals and silica in the mud to form hydrated calcium silicates and aluminum silicates. These reaction products are similar to those responsible for the hardening of cement[3]. With the advent of this new deflocculant, the problem of high temperature solidification has been lessened because these muds possess a low alkalinity and require a minimum of caustic soda or lime for proper maintenance.

To obtain the advantages of an inhibited mud filtrate and better stability at high bottom-hole temperatures, a native mud was converted to a gypsum-ferrochrome lignosulfonate mud on a well near Port Lavaca, Texas. The mud was converted while drilling at 5,020 feet and was used to a total depth of 9,029 feet. The 800-barrel system was treated with 2,400 pounds of ferrochrome lignosulfonate, 2,400 pounds of gypsum, and 800 pounds of lime. Properties of the mud after conversion were:

Funnel viscosity, sec	33
Stormer viscosity, cp	12
Initial gel, g	0
10-minute gel, g	5
pH	8.9

Gypsum, ferrochrome lignosulfonate, lime and carboxymethylcellulose were used for maintenance of the mud during initial operations. At about 7,000 feet, when gel strengths began to develop in the mud, the addition of carboxymethylcellulose was stopped and filtration control was obtained by increasing the concentration of ferrochrome lignosulfonate.

This new chemical has also been used successfully for filtration control while drilling the Anahuac formation. By increasing the concentration to as high as eight pounds per barrel and omitting additions of an organic colloid, the filtrate loss of a mud can easily be maintained at the desired level. The filtrate of this new mud has a higher concentration of calcium ions in solution than a lime mud. This increase in calcium ion concentration makes the mud more inhibitive, causing less hydration and swelling of the shales as they are drilled.

Harris County, Texas. The low-pH-red mud was converted to this new type mud on a well near Baytown,

Texas. The conversion was made at 9,100 feet. The 1,200-barrel mud system was diluted with water initially until the funnel viscosity was 35 sec. During the first circulation, 3,400 pounds of gypsum, 1,800 pounds of ferrochrome lignosulfonate, and 200 pounds of caustic soda were added. The mud properties after the conversion were:

Funnel viscosity, sec	50
Initial gel, g	0
10-minute gel, g	30
pH	11.0
API Filtrate, ml	18
Calcium ion, ppm	840

The conversion was accomplished in five hours without any unusual incidents.

Drilling in Matagorda County, Texas. A gypsum-ferrochrome lignosulfonate-emulsion mud was selected for drilling a well on the east flank of Wadsworth field to control sloughing shales, salt-water flows, and mud solidification due to the high bottom hole temperatures that are often encountered in the area of Matagorda County, Texas.

The new emulsion mud provided good hole conditions while drilling from 6,400 feet to the final depth of 13,988 feet. Maintenance of good mud properties was accomplished by using water, this new deflocculant, and caustic soda to control viscosity and gels, and by using diesel oil and carboxymethylcellulose for filtration control. The main mud problem encountered was air cutting, which was eliminated by additions of ferrochrome lignosulfonate to reduce the viscosity and gels and by adding small amounts of aluminum stearate as a defoamer. The aluminum stearate was dissolved in diesel oil and added to the mud. Approximately 0.25 pound per barrel aluminum stearate eliminated the air cutting.

Salt water contamination in Cameron Parish, Louisiana. In the Umbrella Point, Grand Lake area, of Cameron Parish, Louisiana, a well drilled with a gypsum mud treated with ferrochrome lignosulfonate encountered a salt water flow that increased the chloride ion of the filtrate from 3,000 to 6,000 ppm. The mud weight was increased and little time was lost bringing the flow under control. Ferrochrome lignosulfonate was added to the mud to decrease the viscosity and gel strengths. The total cost of the chemicals to treat the mud was $0.24 per barrel.[1]

Lost circulation and salt water contamination in Calcasieu Parish, Louisiana. A lost circulation zone was encountered while drilling a well in the Gillis-Enginlish Bayou field, Calcasieu Parish, Louisiana. The weight of the mud was reduced from 15.8 to 14.5 pounds per gallon in an attempt to regain circulation. At this point, the well started to flow. The weight was increased slightly to bring the flow under control. When the chloride content increased from 1,700 ppm to 12,000 ppm, caustic soda and carboxymethylcellulose were added to control the viscosity, gel strengths, and filtration rate. The amount of materials needed to condition the mud was small, which indicates the stability of these new muds when contaminated with salt water.

Workover of well accomplished successfully. The low alkalinity of a gypsum-ferrochrome lignosulfonate mud makes possible good stability under conditions of high bottom hole temperatures. Aging tests have been made on both laboratory prepared muds and field samples of the new gyp mud. These tests show that an uncontaminated gypsum mud treated with this new deflocculant is practically unchanged by storage at 300° F. for 160 hours, except for an increase in API filtrate volume. The increase in the filtration would be of little or no concern in a packer mud. Contamination with cement is known to cause the mud to undergo high temperature solidification. This is true of any water-base mud, even a simple bentonite-barite slurry. If this mud can be kept free of cement contamination, it should be a good mud to leave in the annulus. This was proved in southern Louisiana on a field well.

In July, 1957, a gypsum mud treated with ferrochrome lignosulfonate was placed behind the packer on a well in Kenner field, Jefferson Parish, Louisiana. The depth of the well was approximately 11,000 feet and the bottom hole temperature was 200° F. The properties of the mud when the well was completed were:

Weight, pounds per gallon	13.6
Funnel viscosity, sec	60
Stormer viscosity, cp	53
Initial gel, g	0
10-minute gel, g	25
API filtrate, ml	6.8
pH	8.5
Chloride, ppm	3,400
Calcium ion, ppm	900

The packer was pulled without difficulty nine months later. The mud was in good condition. After two circulations, the mud properties were relatively the same as they were at the original completion.

Used in sea-water muds in Louisiana. On a well in Bay DeChene field, Jefferson Davis Parish, Louisiana, a salt dome was penetrated causing an increase in the chloride content to 33,000 ppm. The viscosity and gels of the sea-water mud were easily controlled with ferrochrome lignosulfonate. Hole conditions were good throughout the job. Filtrate loss was also controlled primarily with this chemical.

Another sea-water mud treated with ferrochrome lignosulfonate was used successfully in Bay Marchand field, LaFourche Parish, Louisiana. The typical daily mud properties are shown in Table 1.

As shown in Table 1, the viscosity, gel strengths and filtrate remained fairly constant even though the chloride ion concentration increased from 10,400 ppm to 19,000 ppm. Drilling into a salt-water flow increased the chloride ion to 28,000 ppm, causing an increase in the viscosity and gels. The mud was conditioned with thinner, filtration reducer and caustic soda. During this same period, the weight was increased from 10.1 to 12.5 ppg. The pH was maintained at 8.5 to 9.5 to utilize the greatest inhibiting power of the sea-water. Average tourly treatment for this 900-barrel sea-water mud system was 200

TABLE 1—Typical Mud Properties of a Ferrochrome Lignosulfonate Sea-Water Mud

Date, 1957	6/23	6/23	6/25	6/28	7/1	7/6	7/8	7/10	7/11	7/12
Depth, feet	4316	4499	4867	5113	6200	7791	8230	8463	8561	8666
Weight, pounds per gallon	10.1	10.3	9.9	10.4	10.5	11.5	11.7	12.0	12.4	12.5
Funnel viscosity, sec	37	40	41	44	49	53	48	60	80	74
Initial gel, g	0	0	0	0	0	0	0	0	20	0
10-minute gel, g	30	40	25	40	40	50	40	40	120	85
Plastic viscosity, cp	10	11	10	12	16	13	17	20	24	25
Yield Point, lb/100 sq. ft	7	9	10	13	18	19	27	27	34	32
pH	9.2	9.4	8.6	8.6	9.4	8.1	8.7	8.7	8.2	9.4
API Filtrate, ml	15.0	11.9	8.6	10.8	11.0	10.6	9.1	7.9	10.6	8.9
Solids, percent by volume	12	13	12	14	16	17	21	22	25	
Chloride, ppm x 1,000	10.4	10.4	11.0	11.0	12.5	15.5	17.0	19.0	28.0	27.0

pounds of ferrochrome lignosulfonate, 100 pounds of caustic soda, and 150 pounds of carboxymethylcellulose.

High weight mud used successfully in Oklahoma. A high weight gypsum mud treated with ferrochrome lignosulfonate (15.3 ppg) was used on a well in Washita County, Oklahoma. A 10.4 pounds per gallon emulsion mud with a pH of about 11.5 was used to drill to a depth of 10,550 feet. Casing was set at 10,300 feet. At this time, the 1,200-barrel system was converted without difficulty.

The conversion procedure was as follows:

1. The mud was diluted with 35 percent by volume water to give a 25 cp viscosity.
2. On the first circulation, 8 pounds per barrel gypsum was added.
3. On the second circulation, 4 pounds of ferrochrome lignosulfonate per barrel was added.
4. On the third circulation, 4 pounds of ferrochrome lignosulfonate per barrel and 0.25 pound of caustic soda per barrel were added.
5. The mud was weighted to 12.0 pounds per gallon and the cement plug was drilled. The total time for the conversion was 12 hours.

The mud properties following the conversion were:

Weight, pounds per gallon	10.8
Funnel viscosity, sec	54
Stormer viscosity, cp	46
Initial gel, g	0
10-minute gel, g	0
pH	9.5
API Filtrate, ml	2.9
Calcium ion, ppm	1,280

Over a two-day period, the mud weight was increased to 13.5 pounds per gallon. The filtrate loss was 3.6 ml when the plug was drilled. As the pH decreased, the filtrate decreased to 1.5 ml. The calcium concentration was 1,120 ppm.

The tourly maintenance was:

150 to 250 pounds of ferrochrome lignosulfonate

0 to 35 pounds of caustic soda to control the pH at 8.5 to 9.5

At 11,800 feet, the weight was increased to 15.3 pounds per gallon in anticipation of drilling a high pressure gas sand and to keep the formation from sloughing. The mud properties varied within the following limits:

Funnel viscosity, sec	65	—75
Weight, pounds per gal.	12.2	—15.3
Stormer viscosity, cp	85	—95
Initial gel, g	0	—0
10-minute gel, g	0	—5
pH	8.5	—9.5
API Filtrate, ml	1.2	—1.5
Calcium ion, ppm	800	—1,200
Chloride ion, ppm	800	—1,200
Oil, % by volume	5	—8
Solids, % by voume	23	—35

The new gypsum mud was most satisfactory for the entire job. It was easily prepared and maintained on a low tourly treatment. Resistivity varied very little and made possible good log interpretation.

New gyp mud used in Canada. Operators in Saskatchewan and Manitoba are using gypsum muds treated with ferrochrome lignosulfonate on some of their development wells. Recently, a mud was converted to this new system in the Innisfail area of Canada. The mud properties following the conversion were:

Weight, pounds per gallon	10.4
Funnel viscosity, sec	62
Stormer viscosity, cp	38
Initial gel, g	0
10-minute gel, g	20
API Filtrate, ml	13.2
pH	8.0
Oil, % by volume	4
Solids, % by volume	16

Three pounds per barrel of ferrochrome lignosulfonate and one-third pound per barrel of caustic soda were used for the conversion. A total of 150 pounds of carboxymethylcellulose was added after the breakover and the API filtrate remained in the 11.2 to 11.8 ml range for the rest of the hole. A tourly treatment of 100 pounds of ferrochrome lignosulfonate and 30 pounds of caustic soda was used. The gel strengths remained in the 0.10 g to 0.30 g range.

Indicator solutions available for testing pH. In these new muds pH control is necessary to maintain desirable mud properties. The most suitable pH range has been established at 8.5 to 10.0. pHydrion paper has not proved entirely satisfactory for testing pH in all types of mud. Phenolphthalein and Thymolphthalein indicator solutions have given good results in determining whether the pH falls within the desired range. The following procedure is recommended when using these indicator solutions:

1. Collect the mud filtrate.
2. Add 1 ml filtrate to a clean titrating dish.
3. Add two drops of phenolphthalein solution. If no color develops, the pH is 8.2 or less. If a pink color is observed, the pH is 8.3 or higher.
4. Add 1 ml filtrate to a clean titrating dish.
5. Add two drops of Thymolphthalein solution. If no color develops, the pH is below 10 and probably below 9.3. If a light blue color is observed, the pH is 9.3 to 10. A definite blue color indicates that the pH is higher than 10.

Remarks. Gypsum muds treated with ferrochrome lignosulfonate are economical to prepare and maintain. As a result, they are being well received by oil companies and accepted for use throughout the U. S. and Canada. The rheological properties are not severely affected by anhydrite or salt contamination. The filtration rate can be readily controlled by using higher concentrations of ferrochrome lignosulfonate or by additions of carboxymethylcellulose. The low alkalinity of the mud provides stability under high bottom hole temperatures. Mud resistivity is easily controlled. Low alkalinity permits good electric log interpretation. Caliper logs indicate that the holes remain close to gage.

ACKNOWLEDGMENT

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About the Author

Robert J. Smith joined the Baroid Laboratories in 1952. He has served on the Baroid Mobile Mud Laboratory in Oklahoma, Arkansas, and along the Gulf Coast of Louisiana and Texas. He has also assisted service engineers with drilling mud problems. At the present time he is in the training section instructing new personnel and oil company engineers in the latest phases of Drilling Mud Technology. Smith is a graduate of the University of Rochester, New York with a B.S. Degree in chemical engineering.

Here are interesting facts on Texas' . . .

Subsurface Ouachita structural belt

The frontal structures of this vast and relatively unexplored area have significant oil and gas possibilities

By **Dr. Peter T. Flawn**
The University of Texas, Austin

No convincing geologic reason exists for the condemnation of frontal structures of the Ouachita system as barren without adequate testing. Despite a fairly widespread misconception that all of the structural belt rocks are metamorphosed and that this metamorphism condems a wide swath of foreland facies rocks adjacent to the belt, oil and gas are found along folded and thrust-faulted orogenic fronts elsewhere in the world. In part, this misconception results from a rather loose application of the carbon ratio theory.

But up until now, the Ouachita structural belt, which borders the southern part of the North American continent, must be labeled—unexplored.

The zone of deformation has been variously called the Ouachita structural belt, Ouachita foldbelt, Ouachita-Marathon belt and Llanoria structural belt. It is known that these folded and faulted Paleozoic rocks extend for a distance of more than 1,300 miles from a point in southwestern Alabama through a sinuous course into northern Mexico. It appears certain that the belt extends farther eastward, possibly under northern Florida, and farther southward into Mexico, where it is lost in a confusion of Laramide structures of late Cretaceous—early Tertiary age (the Sierra Madre Oriental).

In its 1,300 miles, the Ouachita structural belt is exposed for a strike length of less than 300 miles. The major exposure (the one from which the feature is named) is in the Ouachita Mountains of western Arkansas and eastern Oklahoma. Here, east-west-trending folded and thrust-faulted Paleozoic rocks of Ouachita facies are exposed in an area about 200 miles long and 50 miles wide. In Texas the Ouachita belt is buried for nearly all of its 900 mile length. It comes to view only in far West Texas, where a structural salient of folded and thrust-faulted Ouachita facies rocks is exposed in the Marathon uplift and again, briefly, in the Solitario uplift. In central Texas, steeply dipping rocks of the front of the belt can be seen in the Turkey Bend area of Lake Travis.

The Bureau of Economic Geology of The University of Texas instituted a major research project covering this feature in 1954. The study was prompted by the widespread interest shown in the Ouachita belt by oil companies operating in Texas. The investigation involves a complete study of the stratigraphy and petrography of rocks encountered in wells penetrating the belt. Data from study of the rocks integrated with information from previous studies of outcrop areas provide a base for tectonic analysis and economic evaluation. Most major oil companies operating in Texas are cooperating in this effort. The project is not yet completed; therefore, structural concepts presented here are subject to modification.

Many articles on problems of the Ouachita structural belt have been written during the last three decades. Unfortunately, there has been some confusion in the meaning of several commonly used terms. Herein, the term Ouachita facies identifies rocks that are lithologically similar to those exposed in the Ouachita Mountains. The term carries no connotations of metamorphism. Some Ouachita facies rocks are metamorphosed and some are not. The Ouachita structural belt is the name given to the belt of deformed rocks. The belt includes deformed rocks of foreland facies, deformed rocks of Ouachita facies and metamorphosed rocks.

Ouachita facies sediments of Ordovician, Devonian and possibly early Mississippian age are predominantly dark shales. Some of these are calcareous or siliceous, chert and novaculite. There are sandstones, siltstones, conglomerates and limestones in the sequence but they are of less importance quantitatively. The lower and middle Paleozoic Ouachita facies is markedly different from the thick deposits of carbonate rock, sandstone and shale of the same age in the adjacent foreland basins. Mississippian-Pennsylvanian rocks of Ouachita facies are orogenic sediments—sandstones, conglomerates, and shales. The main problem is distinguishing between Ouachita facies Stanley lithology and foreland basin Atoka lithology. Both of these units are composed of interbedded sandstone and shale. The separation can be made by petrographic study of the sandstones. Stanley sandstones are fine-grained, angular, poorly sorted, argillaceous, feldspathic, quartz sandstones whereas Atoka sandstones show more rounding, better sorting, contain much less feldspar and are commonly calcareous. The distinction cannot be based on a single sample.

Tectonics of the Quachita Belt. The Ouachita structural belt enters Texas from the north as a buried continuation of the Ouachita Mountains of Oklahoma (Figure 1) and strikes

southward into central Texas. There, it arcs sharply around the Llano uplift and trends westward. In Brewster County, Texas, the belt swings south on a course which can be projected into northeastern Mexico. The sinuous course of the Ouachita chains in the Texas subsurface is controlled by the shape of the old stable craton against which the belt was deformed. The orogenic front is recessed around the unyielding buttress of the Llano uplift and shows strong salients in the "bays" of the old craton.

The belt in Texas is geologically divisible into two segments:

1. The northern limb extends roughly north-south from southeastern Oklahoma to south-central Texas and is clearly a buried extension of the Ouachita Mountains. Ouachita Mountain stratigraphic terminology can be applied to unmetamorphosed beds of the frontal zone.

2. The western limb extending west from the south-central Texas to the Big Bend area of the Trans-Pecos shows structural and lithologic differences from the northern limb. Ouachita Mountain terminology cannot be applied with confidence. Over part of the western limb, the frontal zone of unmetamorphosed rocks is narrow or missing in the subcrop (Figure 1).

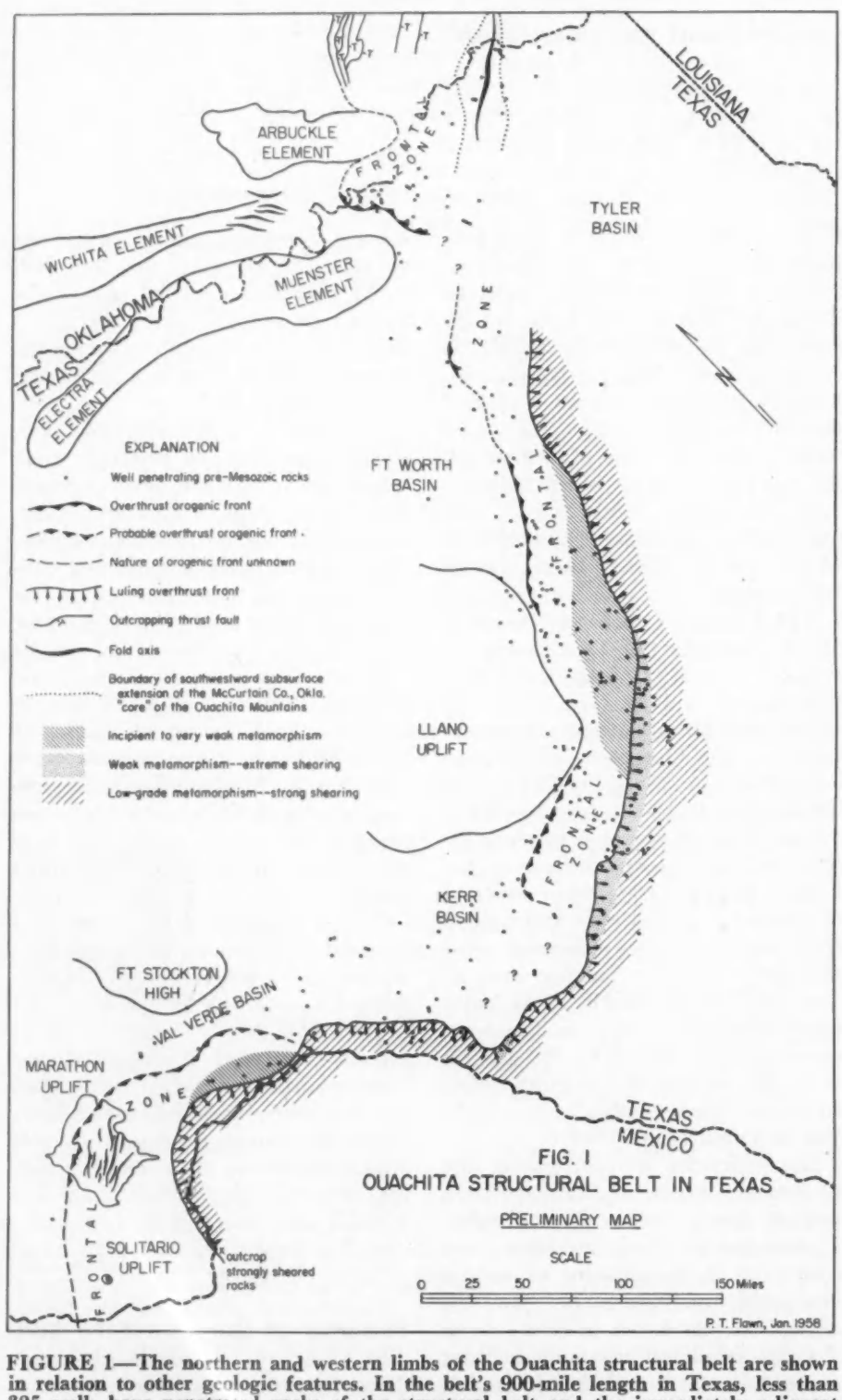

FIG. 1
OUACHITA STRUCTURAL BELT IN TEXAS
PRELIMINARY MAP

FIGURE 1—The northern and western limbs of the Ouachita structural belt are shown in relation to other geologic features. In the belt's 900-mile length in Texas, less than 325 wells have penetrated rocks of the structural belt and the immediately adjacent foreland shelf and basin sedimentary rocks. Such sparse well control indicated that only major features of the belt can be recognized with confidence.

The northern limb of the belt is divisible into a frontal zone of unmetamorphosed, folded and thrust-faulted rocks, a zone of incipiently to very weakly metamorphosed rocks, and a zone of highly-sheared, low-grade metamorphic rocks (Figure 1). The frontal zone (comparable to the Valley and Ridge province of the Appalachian system) is composed mostly of dark shales and sandstones of the Stanley formation. Sporadic cores and a history of excessive hole deviation in many wells indicates that, in many areas, these beds are tilted at high angles. In some areas along the front of the belt (Grayson and Collin counties, Ellis County, and Bell Coryell and McLennan counties), the pre-Cretaceous subcrop is composed of pre-Stanley-Ouachita facies rocks, mostly of Bigfork and Womble lithologies.

In two of these areas (Grayson-Collin counties and Bell County), wells have passed through Ouachita facies rocks into rocks of foreland facies. It appears reasonably certain that these early Paleozoic Ouachita facies rocks have been raised along thrust faults. Minimum displacements on these overthrusts are on the order of five to six miles.

East of frontal zone. East of the frontal zone is a zone composed of dark clastic rocks showing incipient to very weak metamorphism—angular, poorly sorted, carbonaceous, micaceous sandstones, graywackes and silty, slaty shales are dominant rock types. This zone widens southward in the area where the Ouachita belt was crushed against the Llano buttress. No stratigraphic name can be applied to these rocks at this time. They have no counterpart exposed in the Ouachita Mountains. Most probably they are a near-source facies of the Stanley.

Farther eastward, the pre-Mesozoic subcrop is composed of very highly

Continued on Page 174

PART 5: KNOCKING

Know your mud pump—it can save you money

Hydraulic and mechanical knocking must be recognized and corrected for efficient and cost saving operations

By Samuel L. Collier
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THE BEST CURE for a knocking mud pump is an attack based on a clear understanding of knocking, knowing how to recognize it, how to evaluate its severity, and what can be done to correct it. This knowledge will save money by replacing the expensive trial and error method that must otherwise be taken.

What is knocking? A mud pump in operation on a drilling rig is a noisy device. The knocking noise is very prevalent when the pump is not operating properly; however, it is difficult to decide exactly what is responsible for developing these new sounds or what corrective measures should be taken. This is the reason for the wide variation in the description of knocks which are commonly called valve hammer, valve knock, and fluid hammer.

The change in sound may be a result of a mechanical difficulty or an abnormal operating condition.

Mechanical knocking. Mechanical knocks usually give a sharper, more metallic sound than fluid knocking. Mechanical knocks usually occur over a wide range of pump speeds. They are normally of higher pitch and may have a metallic clang. Noise in the power end usually is mechanical, but may be a transmitted noise from the fluid end. A given noise may be louder in some pumps because of the type of construction. Noise in the fluid end may be either a mechanical or fluid knock.

Mechanical knocks usually have one or more of the following characteristics:

- The sound is localized and metalic
- The knock develops after a maintenance job
- The knock occurs at low and high speeds
- It may be more severe with higher pressures at a given speed
- It develops with no change in operation

If the noise is coming from the fluid end, an attempt should be made to localize the source with the aid of a wrench or a tin hat which simulates a stethoscope (See Figure 22). By this simple technique, it usually is possible to locate the origin of the noise. If the noise can be localized, it probably is mechanical knock but if it seems general and hard to locate, it may be a fluid knock.

Knock sometimes develops after a maintenance job. In this case, any parts that have been replaced should be checked to make certain they are the correct size and part number for the specific pump. They also must be installed correctly. In the case of valve replacement, valve lift must be correct to prevent striking against the upper valve guide. Liners must be tight. This should be done while the pump is in operation and the pressure is in the head end of the liner. The rod to pony rod fit and the lock nut must be tight.

Knock resulting from looseness, as described above, usually occurs at all speeds, slow as well as fast, and is also regular rather than random with RPM. The knock is more severe if the pressure is increased at a given pump speed.

A knock may develop after a long, satisfactory run, even though no change in operation such as pump speed, pressure, mud weight and temperature has taken place. This can result from breakage, loosening or wearing of parts, or the accumulation of loss circulation or other foreign material. For example, a partially unscrewed rod could hit the liner cage and very likely develop a mechanical knock in the fluid end. Also power end knocking has resulted from excessive wear of the crosshead slides.

Operational knocks. Operational knocks are sounds that develop from normal operation of the pump. Sounds of this type occur at high and low speeds at the instant a load is placed on the member. The sound that occurs when a drum is struck is a familiar example of an operation knock. If the load develops rapidly, a sound might occur due to a deflection under the load which starts the part to vibrate. This can occur in a pump at the instant the discharge pressure develops in the liner. This puts a high thrust on the rod and power end which sets up vibrations depending on the particular design. Since the pump is designed to handle the operational loads, sounds from this source usually can be ignored.

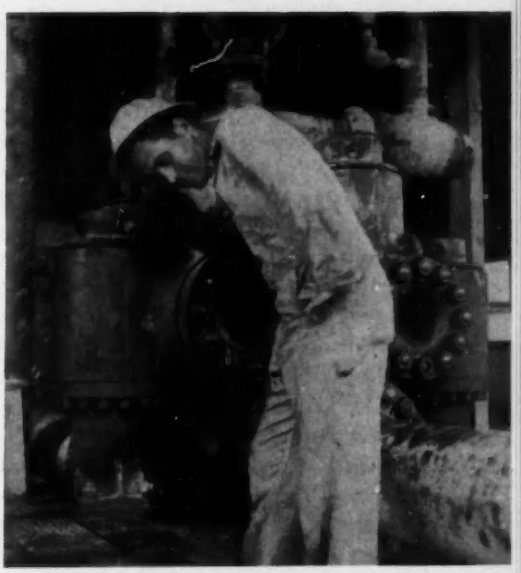

FIGURE 22—A wrench is used as a stethoscope for localizing pump noises.

Hydraulic knocking. Hydraulic knocks may be a result of poor priming, air or water hammer.

A poorly primed pump makes considerable noise when placed into operation even at very low speeds. This

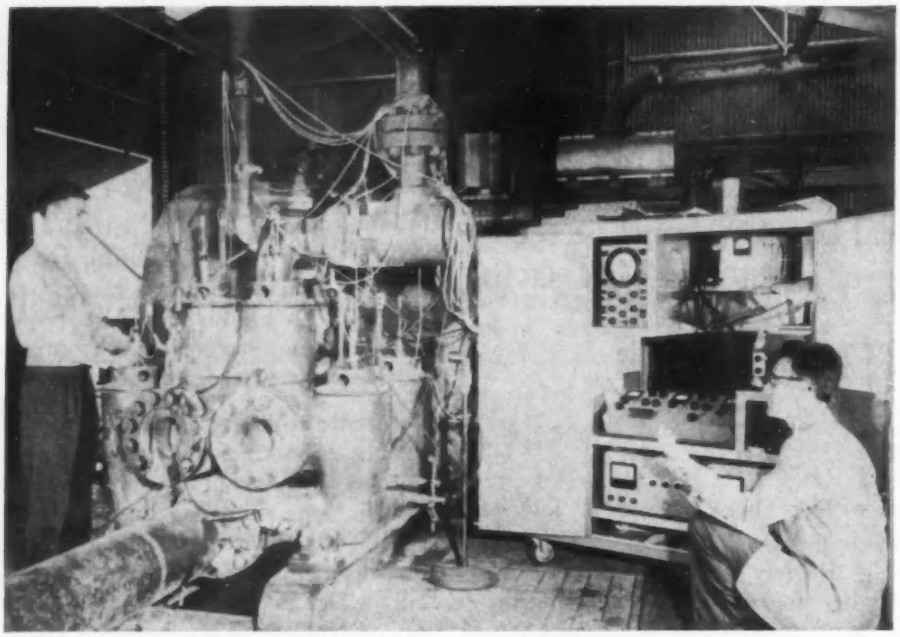

FIGURE 23—Considerable progress has been made in improving oil field equipment through extensive use of varying types of instrumentation.

must be corrected at once to prevent damage to the piston. However, prime may be lost after a period of operation and a knock develops. This may happen if the mud level is low, a leak occurs in the suction line, or if a whirlpool forms in the tank or pit. This admits a large amount of air into the pump and results in incomplete filling. If partial loss of prime is suspected, the knock should remain quite noticeable even at very low pump speeds.

To prevent air entrainment through whirlpools, the suction pipe should be located near the edge of a tank instead of on center. This breaks up the swirling action. Baffles can also be used for the same purpose.

Fluid knock, due to water hammer, has very definite characteristics that have now been established by extensive tests (See Figure 23). These characteristics are behavior of the valves, fluctuation of pump suction pressure, variation of velocity in the suction, and speed of propagation of suction pressure waves.

These tests establish the fact that a hydraulic knock occurs when the pump operation causes the development of a void in a cylinder. When the void is filled, usually just past mid-stroke, the mud strikes the piston causing a hydraulic shock wave and a loud audible knock.

The incomplete understanding of fluid hammer knock has led to considerable confusion. Because of higher operating speeds, this knocking noise is more evident. Therefore, it is important that it be understood.

The actual process that occurs when a water hammer "knock" will take place is as follows:

- **The start of a stroke.** At high speed, the piston is pulled rapidly away from its end position by the engine power delivered through the crank and connecting rod. The acceleration of the piston is very high at this time. The mud in the suction pipe has considerable inertia and will not move as fast as necessary.
- **First third of stroke.** During this period, the piston travels away from the mud, creating the void between the piston and the mud. Then the mud speeds up and pours into the cylinder. However, the piston is moving faster than the mud, increasing the area of the void. This is shown in Figure 24. Up to this point of the stroke, the net volume evacuated by the piston is greater than that filled by the mud.
- **Near mid stroke the void decreases**—Prior to mid strokes, the pistons attains its maximum speed and begins to slow down. However, the mud speed continues to increase and the size of the void decreases. With the piston slowing down and the mud moving faster, the rate of closure or filling of the void becomes quite high.

Impact. Usually, about two-thirds of the way through the stroke, the mud completely fills the void. It now has a much higher velocity than the piston (See Figure 24). Water hammer takes place when the mud velocity is reduced abruptly to the piston velocity. Thus, a stroke which started with poor filling ended with complete filling when the hydraulic knock is heard.

One might think that since poor filling occurred at the start of the stroke the volumetric efficiency would be low. However, when the knock is heard the cylinder is full and filling is actually completed.

The characteristic fluid hammer behavior was measured in a large number of tests. Figure 25 is a typical oscillograph record showing these characteristics which can be compared with Figure 26, showing the normal non-knocking behavior.

The audible sound is the most obvious characteristic of a knock. The intensity shows a large increase (See Trace 13 Figure 25) when the knock occurs at 100-degree crank angle. The knock does not occur at the end of the stroke. It is in the second half of the stroke.

The instantaneous mud velocity in the suction line (Trace 6, Figure 26) shows the same normal variation in velocity as the piston when no knock occurs. During knocking operation, however, instead of the steady variation, the suction mud velocity (Trace 6, Figure 25) shows a steady increase

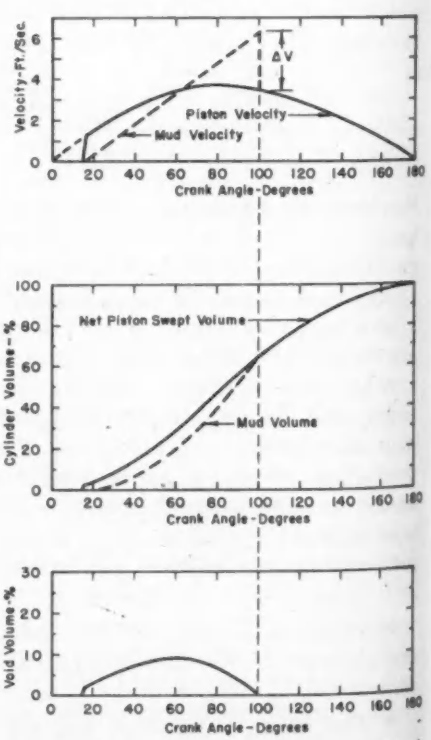

FIGURE 24—Piston and mud speed relationships are very important in determining the causes of water hammer knocking.

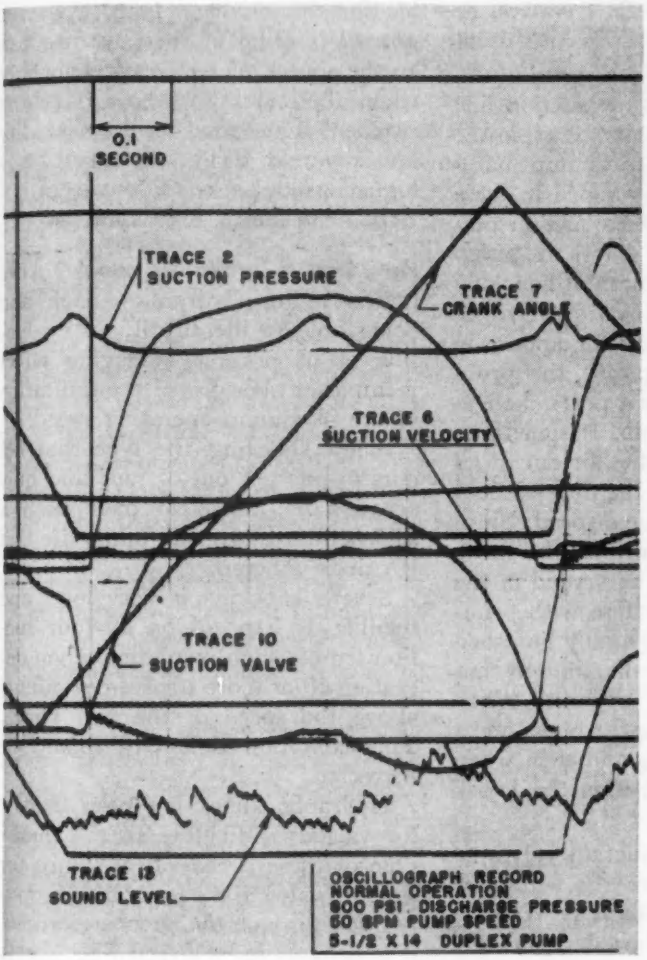

FIGURE 25—When the knock sound is heard, the sound level rises and a surge occurs in suction pressure.

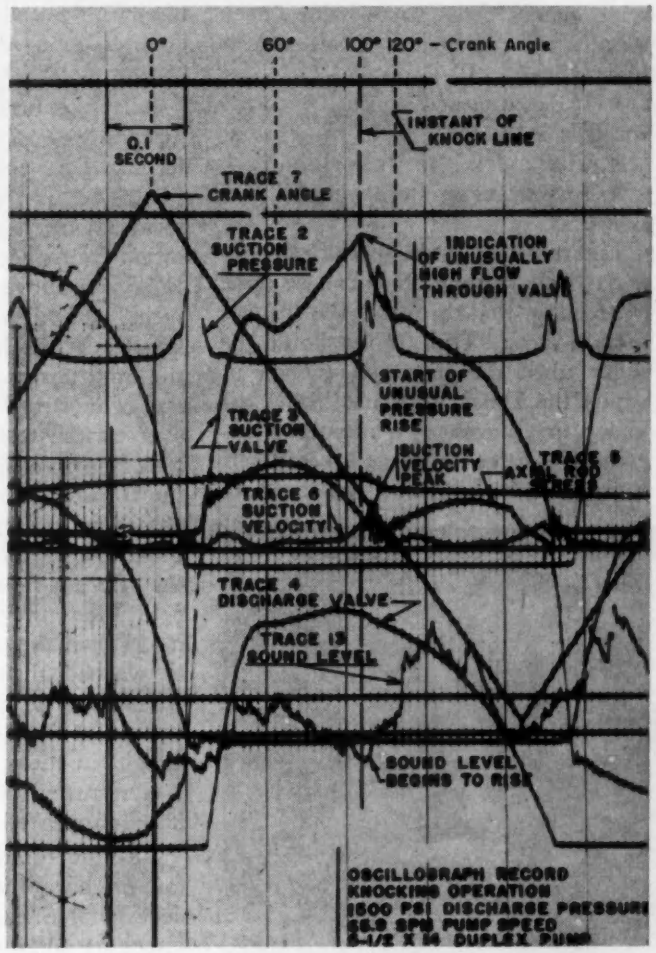

FIGURE 26—Under normal operation the suction and discharge valves have similar patterns of motion.

in velocity over normal. The speed increased to a peak at a 102 degree crank angle and then drops to a much lower velocity instantly.

Since fluid hammer sometimes has been called valve hammer, it is interesting to notice the reaction of the valve to this knocking condition.

Since this test was made on a double-acting duplex mud pump, it is also interesting to compare the action on both sides of the piston. The lift of the valve on the discharge side is shown in Figure 25, Trace 4. It has a very normal appearance compared to the non-knocking valve (See Figure 26, Trace 11). The lift for the valve on the suction side of the piston (Figure 25, Trace 3) is unusual beyond a crank angle of 60 degrees. The suction valve opened normally, however, at this point its lift increased. The lift of a valve is determined, to a large extent, by the amount of mud flowing through it. It is similar to a flow meter and, in this case, confirms the measurement of velocity shown in Trace 6. The valve opened high, but did not strike the upper guide. If the upper guide had blocked the lift, some dwelling would have resulted. It did not in this case because the available clearance was known to be ample. The valve partially closes after the knock takes place and is at its normal position at a 120-degree crank angle. The remainder of the suction valve's pattern and its closure are completely normal.

A quick look at the discharge pressure will confirm that at the instant of the knock nothing unusual occurs. However, this is not the case for the suction pressure (Trace 2) which has a very high peak at the instant of impact. The suction pressure rises because of water hammer at the moment of impact and causes a surge which goes back to the mud tank at a speed of about 3,000 feet per second.

Several important characteristics for hydraulic knock were ascertained from the results of these tests:

1. The knock occurs on the suction side, not on the discharge side.

2. The knock occurs near mid stroke, not at the end of the stroke.

3. The valve is floating open when the knock occurred; therefore, valve hammer is an incorrect term to apply to hydraulic knock.

4. There is no effect on the discharge valves.

5. There is no effect on the discharge side pressure. A discharge dampener will not help this kind of knock.

6. There are high surges in suction pressure and in the suction side of the cylinder.

7. The piston rod load drops because the high surge balances some of the discharge pressure on the other side of the piston.

8. The suction pressure surge causes severe vibration of the suction hose.

9. Knock occurs only at high speed.

10. When the knock occurs, the cylinder is full. Thus, volumetric efficiency is not reduced.

11. Fluid knock can be prevented by increased suction pressure. With these points in mind, it is easier to separate this hydraulic knock from other sounds when testing a trouble-

some pump. This three-point check usually will determine if a knock is hydraulic:

- It does not occur until the pump speed is increased.
- The knock is in the suction side.
- Severe surges occur in the suction line.

Figure 27 shows an operator checking the above item. This can be done by feeling the throb in the rubber suction hose. The throb should be slight until the speed is reached at which the knock is severe. When the knock first develops, a noticeable increase in surge pressure takes place. Pressure measurements are a more accurate method of checking this. The gage (Figure 27) should be installed on the suction line near the pump without a snubber. It then will show very nearly the correct surge.

FIGURE 27—Pump surging may be determined by feeling the throb in the rubber suction hose or by a pressure gage installed on suction line near the pump.

At low pump speeds, the gage will vibrate; however, the range will only cover a few pounds of pressure. This increases with speed until hydraulic knocking takes place. Then the surge will be so high and so fast that the needle will not be visible. If the knock is not hydraulic, of course, this will not occur. These pressures in the first few feet of suction line from the pump can be as high as 200 psi. A gage with a higher range, therefore, should be used.

Variability of knocking is caused by a number of minor points which lead to considerable confusion. Air traps, engine speed variations, low discharge pressure, leaking valves, or changes in mud character are usual causes of spasmodic knocks in pumps.

Air traps occur in the suction line at changes in section, in valves, in the tank siphon, and in the pump manifold. The air that is trapped in these locations often acts as a suction pulsation dampener and allows the pump to be run above the normal knocking speed without the development of knocks. When hunting for knocks in the mud pump laboratory, this problem often arose after a parts changeover on the test pump. It sometimes took hours to bleed the air out of all the traps to recheck the development of a knock at a given speed. Since these traps are not normally harmful, they do not need to be vented in the field unless they interfere with priming. When the air is finally absorbed or washed through the line by entrainment, a knock appears. When the pump is shut down, more air is caught in these traps and then when it is returned to operation the knock has disappeared.

Leaking of some suction valves or low discharge pressure also will cause occasional erratic knock. When a knocking condition first develops, the surge that occurs can be dampened by another suction valve that is leaking or that has such a low discharge pressure on it that it cracks open slightly. When operating at the lower limits of the knocking range, a given pot is influenced by what occurred in the preceding pot. This also causes erratic knocking.

An unexpected variation in knocking was discovered in the mud pump laboratory during a series of knocking tests. All conditions were held as constant as possible with several very careful operators. The pump developed a hydraulic knock for 10 to 15 seconds. This process was repeated for a considerable period of time. The test engineer took oscillograph records of the sound, strokes, pressure, valve movement, and stresses each time the knock started and stopped. Later analysis showed that the engine speed was varying slightly.

When the mud pump speed dropped to 62.4 strokes per minute, the knock stopped; when the speed increased to 63.6 spm, the knock again occurred. While actually running the test, it did not seem possible that such a small change in engine speed (about 20 in 1,200 rpm) could be responsible for this change. Thus, even the normal hunting of the governor can be the source of an erratic knocking when the critical point has been reached. If the mud were cooler, this knock would have occurred at a higher speed, but conditions were just right for a knock at 63 spm.

How bad is hydraulic knock? After understanding hydraulic knock and being able to identify it, an evaluation of its possible damaging effect is important because of the limitation of the maximum operating speed.

Slight knocking, the type that occurs in one pot out of four and only occasionally, seems to have such a slight effect on over-all pump life that it can be ignored.

Severe knocking is very loud and regular. It happens on all four suction strokes each revolution when operating 10 or more strokes per minute above the speed of the first knock. This condition definitely should be corrected.

Hydraulic knock has been blamed for various difficulties in the pump. One of these is the valves. Since the suction valve is floating in an open position through the knocking process, it is unlikely to be affected by knocking. Surge in pressure occurs under a discharge valve. This unusually high rate of pressure rise balances pressure over valve but can not open the valve at normal pump pressure and should have little effect on it.

The surge pressure is very high at the source of impact. Pressures as high as 1,000 psi have been recorded in the cylinder. The surge decreases with distance from the source. When the knock causes a very high pressure on one side of the piston, it balances the pressure on the other side of the piston. Since the surge pressure rises to its high value very rapidly, the stress in the rod and the load on the bearings *decrease* just as fast.

If operating at 1,000 psi discharge pressure and a severe knock occurs, causing a 1,000 psi surge in the cylinder, the stress in the rod will momentarily drop to nearly zero. The rod load will return to the stress caused by the 1,000 psi discharge pressure immediately. Since this happens just after mid stroke, it is similar to producing one extra stress reversal on each movement of each piston. A single occurrence such as this is unimportant. If knocking is continuous, twice as many stress reversals would be pro-

duced. Although the fluid and parts do not usually fail from corrosion fatigue, these added reversals would have a detrimental effect. The pressures that develop from knocking are unlikely to exceed the recommended manufacturer's pressure ratings and failure from that source should not be expected.

The doubling of load cycles might have a more adverse effect on bearing life. Bearing life is directly proportional to operating speed which equals the number of times a load has been applied. Since severe knocking doubles the number of load applications, the worst effect it might have would be to cut the bearing life in half. This has not been established positively because several tests would be required in which the pump must be run in a severe knocking operation at full power for the entire test. Since the pump is not usually operated at full power, the bearings will last much longer than the full load rating of 30,000 hours or more. A new pump run with severe knocking at full power for 15,000 hours might develop bearing trouble. The usual field pump should only have its bearing life slightly reduced by occasional knocking operation.

Knocking has been suspected as a possible source of low volumetric efficiency. This is based on the concept that knocking is caused by incomplete filling. However, this is not the case since the volumetric efficiency is the same with and without hydraulic knock. This is to be expected since the knock does not occur until the void actually fills completely.

Knocking limits operating speed. The development of hydraulic knocking only limits the maximum speed at which the pump should be operated. It does not immediately impede the over-all efficiency of the drilling operations. However, definite steps should be taken to increase safe operating speeds, such as:

- Better suction systems.
- Use of dampeners.
- Use of super chargers.

These are described more fully in previous articles.

The knocking problem, once fully understood, can be evaluated and eliminated without a long trial and error period. This will save time, reduce expense and obtain better pump and rig performances.

TO BE CONTINUED

For Your PRODUCTION File

PART 5

How to calculate recovery from a gas reservoir

This easy-to-understand example problem shows the application of the material balance method to gas reservoirs in actual practice

By Frank W. Cole
Assistant Professor of Petroleum Engineering
University of Oklahoma, Norman

THE MATERIAL BALANCE equation for a gas reservoir can be used to advantage to determine:

- Amount of gas originally in place.
- Pressure-production history of the reservoir.
- Recoverable gas.
- Size of the reservoir.

The determination of the amount of gas originally in place already has been presented. However, the amount of gas originally in place also can be calculated by using the well known gas laws:

$$\frac{P_o V_o}{Z_o T_o} = \frac{P_s V_s}{Z_s T_s} \qquad (1)$$

$$V_s = \frac{P_o V_o Z_s T_s}{P_s Z_o T_o} \qquad (2)$$

The subscripts o and s refer to original conditions and standard conditions, respectively.

The pressure production history of a gas reservoir can

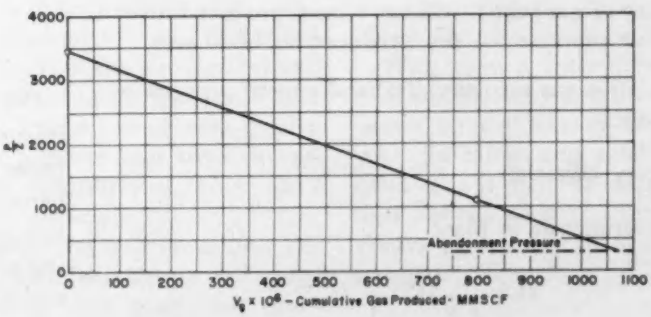

FIGURE 1—Pressure-production history.

be predicted by using the material balance equation as follows:

$$G\frac{1}{v_o} = V_g + G\frac{1}{v} \quad (3)$$

rearranging:

$$V_g = G\frac{1}{v_o} - G\frac{1}{v} \quad (4)$$

However, by definition from a previous article (Part 4):

$$v_o = 0.00504\frac{Z_oT_o}{P_o} \quad (5)$$

$$v = 0.00504\frac{Z_1T_1}{P_1} \quad (6)$$

combining equations (4), (5), and (6) yields:

$$V_g = \frac{G}{0.00504\,\frac{Z_oT_o}{P_o}} - \frac{G}{0.00504\,\frac{Z_1T_1}{P_1}}$$

$$= \frac{G\left(\frac{P_o}{Z_o}\right)}{0.00504\,T_o} - \frac{G\left(\frac{P_1}{Z_1}\right)}{0.00504\,T_1} \quad (7)$$

multiplying both sides of equation (7) by 0.00504 T_o yields:

$$V_g(0.00504\,T_o) = G\left(\frac{P_o}{Z_o}\right) - G\left(\frac{P_1}{Z_1}\right)\frac{T_o}{T_1} \quad (8)$$

However, reservoir temperature does not change, therefore $T_o = T_1$. Solving equation (8) for $\frac{P_1}{Z_1}$:

$$\frac{P_1}{Z_1} = \frac{P_o}{Z_o} - V_g\left(\frac{0.00504\,T_o}{G}\right) \quad (9)$$

Equation (9) is of the form $y = mx + b$ which plots as a straight line on coordinate graph paper. Thus, a plot of $\frac{P}{Z}$ vs V_g should result in a straight line.

Equation (9) is useful for determining graphically the amount of gas to be produced to any pressure. Utility of the equation can be illustrated by an example problem:

The following information on a closed gas reservoir is available:

Original Pressure, = 3,000 psia
Reservoir Temp., = 175°F. + 460° = 635° Absolute
Specific Gravity of Gas = 0.60
After producing 400,000,000 scf, the reservoir pressure is 2,000 psia.

Determine:

(1) Amount of gas originally in place.

(2) Amount of gas which will have been produced after reservoir pressure has been reduced to 1,000 psia.

(3) Cumulative gas recovery, if abandonment pressure is 300 psia.

(4) Recovery efficiency.

(1) Gas originally in place.

$$G = \frac{V_g v}{\left(\frac{v}{v_o} - 1\right)} \quad (a)$$

$$v_o = 0.00504\frac{Z_oT_o}{P_o} = \frac{(0.00504)\ (0.88)\ (635)}{3000} \quad (b)$$

$$v_o = 0.000940$$

$$v = 0.00504\frac{Z_1T_1}{P_1} = \frac{(0.00504)\ (0.89)\ (635)}{2000} \quad (c)$$

$$v = 0.001425$$

then,

$$G = \frac{(400{,}000{,}000)\ (0.001425)}{\left(\frac{0.001425}{0.000940} - 1\right)} \quad (d)$$

$$= 1{,}100{,}000 \text{ bbls. of reservoir space}$$

$$\text{Gas Reserve, SCF} = G\frac{1}{v_o} = 1{,}100{,}000\left(\frac{1}{0.000904}\right) \quad (e)$$

$$= 1{,}170{,}000{,}000 \text{ SCF}$$

(2) Gas produced when reservoir pressure is 1,000 psia.

$$V_G = G\frac{1}{v}\left(\frac{v}{v_o} - 1\right) \quad (a)$$

$$v_{1000} = 0.00504\frac{(0.92)\ (635)}{1000)}$$

$$= 0.00295 \quad (b)$$

now,

$$V_G = 1{,}100{,}000\left(\frac{1}{0.00295}\right)\left(\frac{0.00295}{0.00094} - 1\right) \quad (c)$$

$$= 798{,}000{,}000 \text{ SCF}$$

(3) Cumulative gas recovery (abandonment pressure = 300 psia).

$$V_G = G\frac{1}{v}\left(\frac{v}{v_o} - 1\right) \quad (a)$$

$$V_{300} = 0.00504\,\frac{(0.97)\ (635)}{300} \quad (b)$$

$$= 0.01036$$

then,

$$V_G = 1{,}100{,}000\left(\frac{1}{0.01036}\right)\left(\frac{0.01036}{0.00094} - 1\right) \quad (c)$$

$$= 1{,}062{,}000{,}000 \text{ SCF}$$

(4) Recovery efficiency.

$$\%\ \text{R.E.} = \frac{\text{Cumulative Production to Abandonment}}{\text{Original Gas in Place}} \times 100$$

$$= \frac{1{,}062{,}000{,}000}{1{,}170{,}000{,}000} \times 100$$

$$= 90.8\%$$

A plot of $\frac{P}{Z}$ vs. V_g is shown in Figure 1. As previously discussed, this plot is a straight line on coordinate graph paper, and after a reasonable amount of gas (at least 25 percent of the reserve) has been produced this straight-line plot will provide a satisfactory procedure for estimating recoverable gas. The calculated points from parts (2) and (3) of the example are shown on the graph.

TO BE CONTINUED

The man most likely . . .

If you really want to be a failure, there's really nothing to it! Here's a system which will assure you of being a resounding flop. Professional shortcuts revealed—on the job training possible!

By Max E. Stansbury
Continental Pipe Line Co., Ponca City, Okla.

THE REASON there are so few truly colossal failures in this world is because many of the persons striving toward that goal lack concentration and direction. They are like the famous Leacock character who leaped into the saddle and galloped off in all directions. The man who succeeds as a complete failure will choose the road that best suits his type and will steadily canter toward that goal.

I have picked five excellent routes to outstanding failure and have named them after streets and highways. They are the "Toll Road," the "Corduroy Road," the "Freeway," the "Dead End Street," and the "High Road." Any one of them offers opportunity for the man who wants to really make a mark in the failure field. Let's look at each.

The Toll Road. This is one of the most scenic routes to failure. In this group you will have Men-of-Distinction for company; the meteoric-risen veeps, the ball-of-fire geniuses in most any line. With this road, however, it will take you longer because you first must be a success before you can fail.

Gone are the days when an ordinary ulcer or cardiac condition could qualify you as a "Toll Road" failure. Modern medicine patches you up, and within a few short months you are back on the job. You have to do better than just ulcers or a mere heart attack in this modern age, so try a complete nervous breakdown.

No Lunch. Suppose everyone recognizes you as an able fellow, doing an excellent job—that makes it pretty tough to fail. But under this system, you're not hopelessly doomed to a life of success. In those circumstances it is a good idea to begin thinking of yourself as indispensable and infallible. Skip lunch. You are too busy to eat. Fill your briefcase, your desk and your mind with reams of work details. Refuse to allocate any work to assistants or subordinates. They can't do it right anyway!

Let yourself be a little miffed because the committee adopts Bill's suggestion rather than yours. Let yourself be envious because it's at Dick's desk that the big boss usually stops for a bit of chit-chat when he is visiting the salt mines.

Hate or envy, for any reason, can really use up a lot of emotional energy. And with your efforts devoted to hate and envy, you will be well on the way toward an emotional blowup that will take you out of the picture.

Develop a thin skin and take everything personally. Learn to feel that every department instruction and every company bulletin is actually directed right at and against you. Reach the point where if one of your company brass hats says, "Good morning" to you as you enter the plant, you spend the rest of the day fretting about what he meant by that remark.

With only a little effort you can read slights into actions or remarks where no slights were meant. These you can nurse into really important cases of self-pity—to such an extent that you can become a hypochondriac always in search of a cure for an imaginary illness.

Avoid Decisions. One of the most

Try being an "idea snatcher." All you have to do is find some bright young engineer who is willing to confide his ideas to you. Then merely corner the plant manager and expound those ideas as your own.

helpful devices in your struggle upward in the failure field is to run from making decisions. If you really put your mind to it, you can reach a situation where you will never finish a task because you are busy rationalizing, postponing, seeking and fussing to find the perfect solution. Keep your finger on every tiny detail. Insist on personally handling everything that comes along so that you can overload your brain with unnecessary stimuli.

Then, as sort of an over-all campaign, on any job or project you undertake, set your sights so high that you can't hope for full accomplishment. Using this method, even though you have done a pretty good job, you are left with dissatisfaction and frustration which gnaw on your nerves and emotions. Another advantage is that you can waste a great deal of time in self-pity and self-condemnation, and you won't have time to go out and accomplish another pretty good job that satisfies everyone but you.

Work like a dog on every job and neglect your health, your family relationship and your friends so that there will be no rest for your body, for your nerves, or emotions. Only then can you assure yourself that you are really on your way along the "Toll Road" of failure.

Maybe some of you are unwilling to spend the time necessary to become a success before achieving failure. Then the "Toll Road" is not for you.

There are others!

The Corduroy Road. This route to failure is one reserved for the rough, tough, he-man type. If you are ill-mannered, talk too loud and too long, the "Corduroy Road" is the one for you.

It is a rugged road and requires constant affirmative action. You must drop any cultural qualities that you have. A liking for music, literature, art—that stuff's for sissies. For you, the three B's are beef, brawn, and booze. Any attempt to engage you in conversation about anything except sports—or maybe women—brings from you nothing but derision.

In voicing your opinions, you will be very decided and positive in your views. You are required to take it as a personal affront if anyone suggests views contrary to yours. In that case, you can disagree, good and loud, perhaps making a few reflections on the other man's intelligence or motives.

This is a particularly handy approach to use on people you have just met. Right away they can mark you down as a man they want nothing further to do with, and you are therefore well along the "Corduroy Road" to failure, unhandicapped by any new friends.

Be a Free Swinger. One of your biggest assets in your travel along the "Corduroy Road" to failure is to be a heavy drinker, but beware of this course if all you do is slide under the table. As a result of your drinking, be bellicose and antagonistic. The happy drunk, the weeping drunk, people will tolerate, even forgive. But the drunk who wades in there swinging has marked himself as a first-class heel that no one wants around.

Drunk or sober, be quick to anger. Frequent violent outbursts of temper are valuable in causing people to avoid you.

At the first sign of adversity, let go completely! Spend valuable time giving associates and subordinates large pieces of your mind. This will make people think you'd be much happier and less bothersome in a nice quiet sanitarium, weaving bright rugs. As an excuse, you can blame the necessity to relieve nervous tension, or the rapid pace of your job. You can always comfort yourself with the thought that most great persons are temperamental.

Now, in contrast with the "Corduroy Road" traveler—rough, rugged—is the smoother, urbane "Freeway" fellow.

The Freeway. Here is another road to outstanding failure. On the "Freeway" you can spend your time on the job dreaming about a promotion, transfer, or a higher paying job with another company. Or, you can devote your thoughts to entering a business for yourself. For instance, try to think up a product that costs a dime, sells for a dollar, and is habit-forming.

Don't regard your job as a reason for living, but only as a means for earning a living. You must watch yourself so that you don't develop an interest in your work so that you actually enjoy it at times. That might be fatal to your hopes for failure.

Be very open in expressing your dissatisfaction with your pay, the conditions under which you have to work, the boss' ability and his feeling toward you. Never fail to criticize company policies or practices, whether or not they are regarded as good. And while you are at it, don't display any loyalty to your employer or company. Attack the quality of the company product, and don't go out of your way to use it yourself or to recommend it to your acquaintances.

A Case History. Always oppose the best interests of your industry or your company. A good gimmick along this line is the percentage depletion; let me give you a detailed case history of how a "Freeway" failure can go to work.

Percentage depletion, as you know, is the 27½ percent deduction which our country's income tax laws allow

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Ride in style on "The High Road." Buy a Cadillac on a Chevy income—really go for partying so you will always feel hung over.

those fellows who find oil. Similar allowances are made in mining and in other businesses where there is a big risk to the investor who puts up the money, and when the production makes it a "wasting asset"—that is, once you take it out it's gone and irreplaceable except by new discovery. You deplete the product by producing it.

Percentage depletion is not very well understood by the general public, and it has been represented by its enemies as a tax "loophole." Yet practically everyone understands that depreciation on a plant or piece of machinery that produces a product is an allowable and justifiable income tax deduction. Percentage depletion for oil produced is the equivalent of depreciation on a plant. Because you're in the oil business, your friends outside the industry will want your views on percentage depletion.

As a man on his way along the "Freeway" route to failure, you should influence your friends to believe that percentage depletion is tax evasion by the big-money boys; that it shouldn't be allowed for the oil industry. By so doing, you can really sabotage your company and your industry; and since your objective is success as a failure, you have thus struck a telling blow for yourself.

Be an Idea-Snatcher. It helps in cruising down the "Freeway" road to failure if you can find a bright young engineer or scientist who will confide his ideas to you. Then you can contrive to encounter the plant manager and can modestly start out something like this, "I know so little about these things, and undoubtedly you have thought of it first, but it seems to me . . . ," then expound, as your very own, the pilfered idea. Enough scheming of this kind and pretty soon all your associates and superiors make every effort not to impede your progress along the "Freeway" road to failure.

You must also be careful what you read. It might veer you from your objective of being a failure. For instance take this quotation from Lawrence Appley, president of the American Management Association:

"If one foreman is motivated by a wish to be of service and sees his job as an opportunity for service, he has an influence that is farther reaching than he himself may realize. For if he helps one person who works for him to be a better worker and a better citizen, that one person will be a more constructive influence in his own family, among his friends, and in the community in which he lives. Multiply that by 15 or 20 individuals in the foreman's department and we can see that he is rendering a far greater service than would seem to lie within the boundaries of his job.

"At the same time, such a foreman is attaining the results for his company that are most to be desired, and he is destined to progress to greater and greater management responsibilities."

You had better watch that kind of stuff. First thing you know you'll be thinking it's sound and logical. Then you'll believe it and start practicing it. If you do, brother, you're a dead duck so far as being a successful failure.

"Now," you may ask, "what if I'm not the "Toll Road" type . . . or not rugged enough for the "Corduroy Road" . . . and can't qualify for the "Freeway" . . . what do I do then?"

That's a good question. It encourages me to discuss the "Dead End" and "High Road" routes to failure.

The Dead End Street. To make the grade as a failure in the "Dead End Street" class, it is not enough to be just a procrastinator. That is a big help, but it has to go deeper. Instead of letting letters, reports and memos just clutter up your desk without your taking any action, put them in your desk drawer and forget them! After two or three crises—with the causes found in your desk—you'll be marked as a man who will go far as a failure.

On the "Dead End" road to failure, you must always stand on your dignity and sit on your prerogatives. Protocol, the amenities, and the red tape must always be observed. There is no room in you for levity, hearty laughter, camaraderie, or just plain friendliness. If anyone encroaches just one tiny bit on your prerogatives, or sticks his nose in your field of endeavor, see that the whippersnapper is properly and swiftly put in his place. If you are violently jealous of what you are sure are your very own rights, your very own business, then you can keep practically everyone from helping you.

Stick to the Rules. It is a nice touch to be a stickler for the rules, regardless of the circumstances. This is particularly helpful in human relations or in dealing with people. In any written rule or law, there will be found flaws that work injustices in certain circumstances. Be sure you insist upon the application of the letter of the law in those cases.

A further refinement of the "Dead End Street" approach is to check every possible angle on every problem, regardless of its importance. You can really have a field day on some minor type of problem while you seek everybody's opinion as to the solution and make surveys to see what other companies have done in similar circumstances.

But Be Careful. A word of caution here, however. The process of checking other people's opinions and industry practices can be a valuable tool on an important problem. If you slip and go through the process on a problem that really deserves that attention, you're liable to wind up with a feather in your cap instead of making

Suppose SUPPLY ROW should become GHOST ROW

YOU WOULD BE LOST WITHOUT ALL THE SERVICES YOU HAVE LEARNED TO TAKE FOR GRANTED.

Almost everyone has seen the ramshackle remains of supply centers which have out-lived their usefulness. It's natural and logical to move on when activity ceases and the wells are pumped dry.

But what an unhappy phenomenon it would be to observe the operations of our Supply Industry, modern and useful to the point of indispensability, grind to a halt because the wells of profit have gone dry.

IT COULD HAPPEN — TOO MUCH IS BEING EXPECTED FOR TOO LITTLE PROFIT.

This dilemma can be avoided by your supporting your Supply Industry and helping it make a reasonable profit. It's the only way to perpetuate this vital segment of the petroleum industry.

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LARKIN LEADERSHIP HAS BEEN EARNED BY YEARS OF DEPENDABLE PERFORMANCE

"Some of us who think we have an inferiority complex find out that we're mistaken. We have no inferiority 'complex'—we're just plain inferior."

progress along the "Dead End Street" to failure.

However, even in the case of such a mistake don't panic—you can sometimes redeem yourself and make the situation an aid to your campaign for failure. For instance, having mistakenly assembled all the pertinent facts on a problem that warranted the effort and the time, write a report so long-winded and so disorganized that your busy boss will discard it in disgust. Or leave out some essential, such as the estimate of the cost, so management has to refer it back to you.

Little refinements like those are the mark of a man entitled to travel the "Dead End" road to failure.

The High Road. Probably the most exciting road to failure is the "High Road." This category is the "Living It Up" school of failure. For those who really qualify, it leaves many pleasurable and erotic memories.

As a modest beginning, you can live beyond your means. No piddling efforts like buying cars, houses, and television sets on time will do, however. Be big about it. On a Chevrolet income, go in debt for a Cadillac. That will, in turn, lead to other mismanagement of your funds and finally, on a stack of unpaid bills, you can climb to success as a failure.

Go in heavily for expensive partying and debauchery that leaves you all hung over on the job. Being thus unable to perform will act as insurance that nobody will want you around the job.

Try Two. Above all, involve yourself with many, many women. For almost any man even one woman is sometimes a strain. But for the man who wants to be a "High Road" failure, it's a case of gritting your teeth in determination and making the necessary sacrifice by carrying on with at least two. And it's not enough that you have a clandestine girl friend. It's almost axiomatic that nobody cares particularly about your private affairs. It's only when you flaunt your indiscretions in their faces that the decent people become disgusted with you.

See to it that your girl friends call your office frequently, or that your wife is so disturbed she seeks help from your associates. Or take your little playmate to social affairs where your friends and acquaintances are put on the spot by having to accept or reject her.

Getting involved in newspaper scandals or being named as the "other man" in divorce proceedings is needlessly dramatic, even though it might be effective.

You can also be quite effective, and possibly more obnoxious, just by making a few passes at the wives of fellow employes. This is probably the fastest way to achieve the status of a "High Road" failure.

Now, those are the five basic roads to achieving outstanding failure. You can have combinations, clover-leafs, detours and bypasses, but the fundamental routes will always be there:

1. The Toll Road
2. The Corduroy Road
3. The Freeway
4. The Dead End Street
5. The High Road

Somebody could well now ask what road did I take in qualifying myself to speak so authoritatively on failure. I must admit that I didn't practice what I've been preaching.

I followed none of those routes. I'm a natural. I didn't have to work at failure in any of the ways I've outlined for you.

Some of us who think we have an inferiority complex find out that we're mistaken. We don't have an inferiority "complex;" we're just plain inferior. That puts us in what we might call the "Parking Lot" class of failures—no effort, no striving; just plain natural aptitude. Less than one percent can qualify as "Parking Lotters," however. Most of you will have to work at it through the routes I've been telling you about.

Think Big—Think Failures. In all of the routes to failure, and even in the "Parking Lot" method, your attitude is the most important single factor. You can't be just casually interested if you are to reach your goal. Only when you find that your mind is constantly occupied with thoughts of failure can you say that you've achieved the proper attitude. When you're first pointing toward failure, it's all right to think about it on a part-time basis. But if you aspire to be a real resounding flop, you must develop a full-time attitude.

It is sort of like the lady who called the desk of her apartment hotel to complain that someone was banging away at a piano in the suite next to hers. The clerk explained that the piano was being played by Liberace, who was practicing for his concert that evening. The lady immediately called several of her friends to come in a hurry to her apartment. They listened with attention and appreciation to sparkling piano music by Liberace. The sounds from the next suite were the same. Only the lady's attitude had changed.

Watch your attitude. You, too, can learn to fail. Work at it, and I'll guarantee that ex-friends and former coworkers will vote for you as "The Man Most Likely to Fail."

—The End

About the Author

Max E. Stansbury is manager of industrial relations for Continental Pipe Line Company, Ponca City. He received his B.A. degree from Oklahoma State University and his LL.B. degree from the University of Oklahoma. Stansbury joined Continental Oil Company in 1936 where he worked in the company's Land, Legal and Industrial Relations staffs. Prior to moving to Continental Pipe Line several months ago, Stansbury was assistant manager of Industrial Relations for Continental Oil, Houston, where he handled general employe and industrial relations matters.

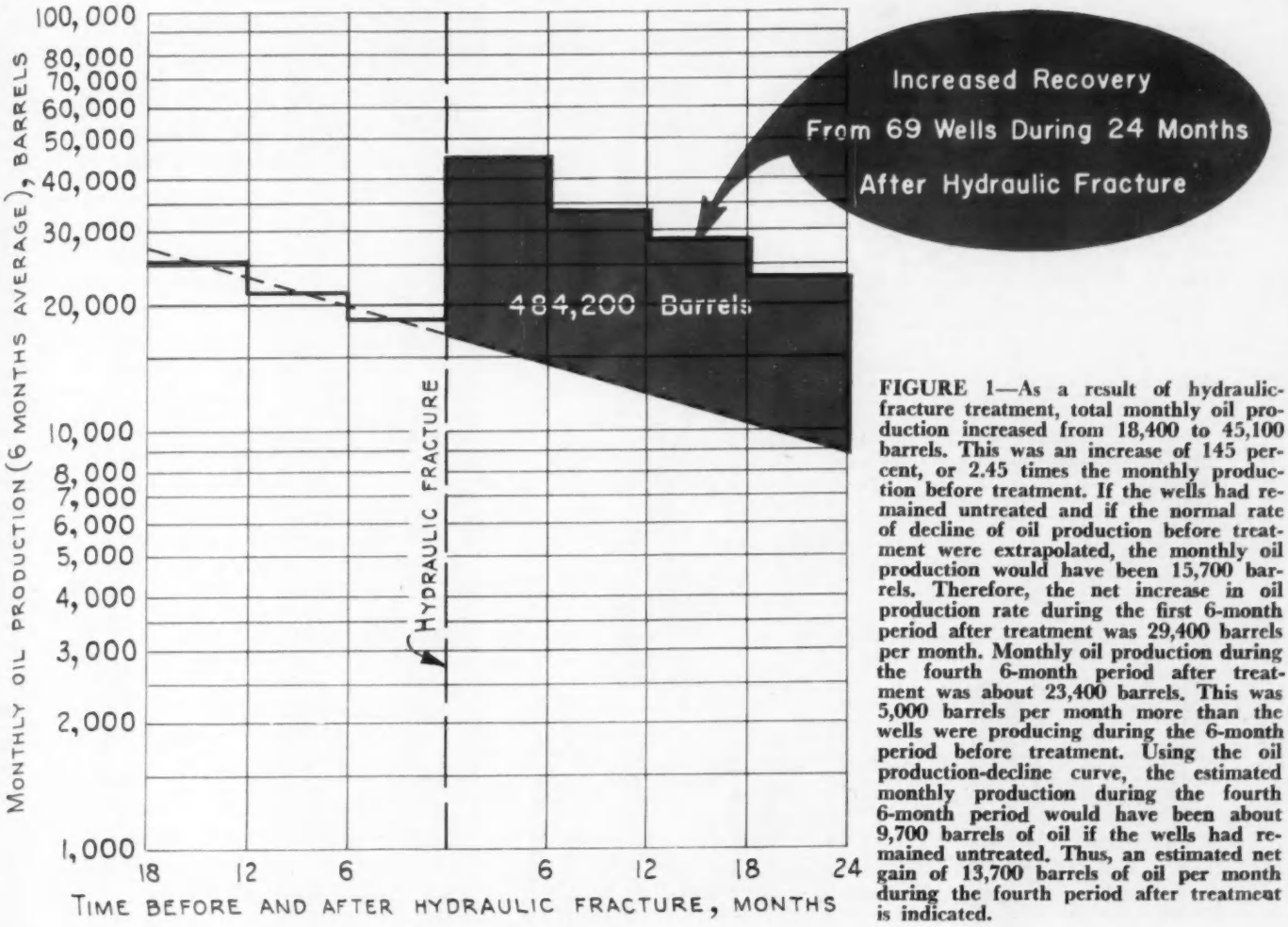

FIGURE 1—As a result of hydraulic-fracture treatment, total monthly oil production increased from 18,400 to 45,100 barrels. This was an increase of 145 percent, or 2.45 times the monthly production before treatment. If the wells had remained untreated and if the normal rate of decline of oil production before treatment were extrapolated, the monthly oil production would have been 15,700 barrels. Therefore, the net increase in oil production rate during the first 6-month period after treatment was 29,400 barrels per month. Monthly oil production during the fourth 6-month period after treatment was about 23,400 barrels. This was 5,000 barrels per month more than the wells were producing during the 6-month period before treatment. Using the oil production-decline curve, the estimated monthly production during the fourth 6-month period would have been about 9,700 barrels of oil if the wells had remained untreated. Thus, an estimated net gain of 13,700 barrels of oil per month during the fourth period after treatment is indicated.

In North Texas' Strawn . . .

Hydraulic fracturing pays off

Here's proof:

- **Increased primary recovery**
- **Lower decline rates**
- **High initial productivity, with average production rates increased up to 150 percent**

By Thomas M. Garland, Petroleum Engineer, and
W. C. Elliott, Jr., Chief, U. S. Bureau of Mines
Wichita Falls, Texas

THE U. S. BUREAU OF MINES has studied the effects of hydraulic fracturing upon oil recovery from the Strawn formation of North Texas. The following pertinent conclusions were drawn from this study:

- Ultimate recovery of oil by primary means was increased by the treatments.
- For approximately 71 percent of the wells studied, the oil production decline rate, after a successful treatment, was equal to or less than the decline rate before treatment.
- During the first six months after treatment, the average production increase was 150 percent, or 2.5 times, greater than the production rate during the six-month period before treatment.
- The average production rate during the first six months after fracture treatment was approximately the same as the rate 30 to 36 months before fracture treatment.
- Hydraulic-fracture treatments created an increased production rate that did not decline to the pre-treatment level for about 30 months.
- The age and condition of a well are of primary consideration. Treatment of old wells in which the reservoir energy was depleted resulted in substantial increases in production. However, even greater benefits were obtained from wells treated before the

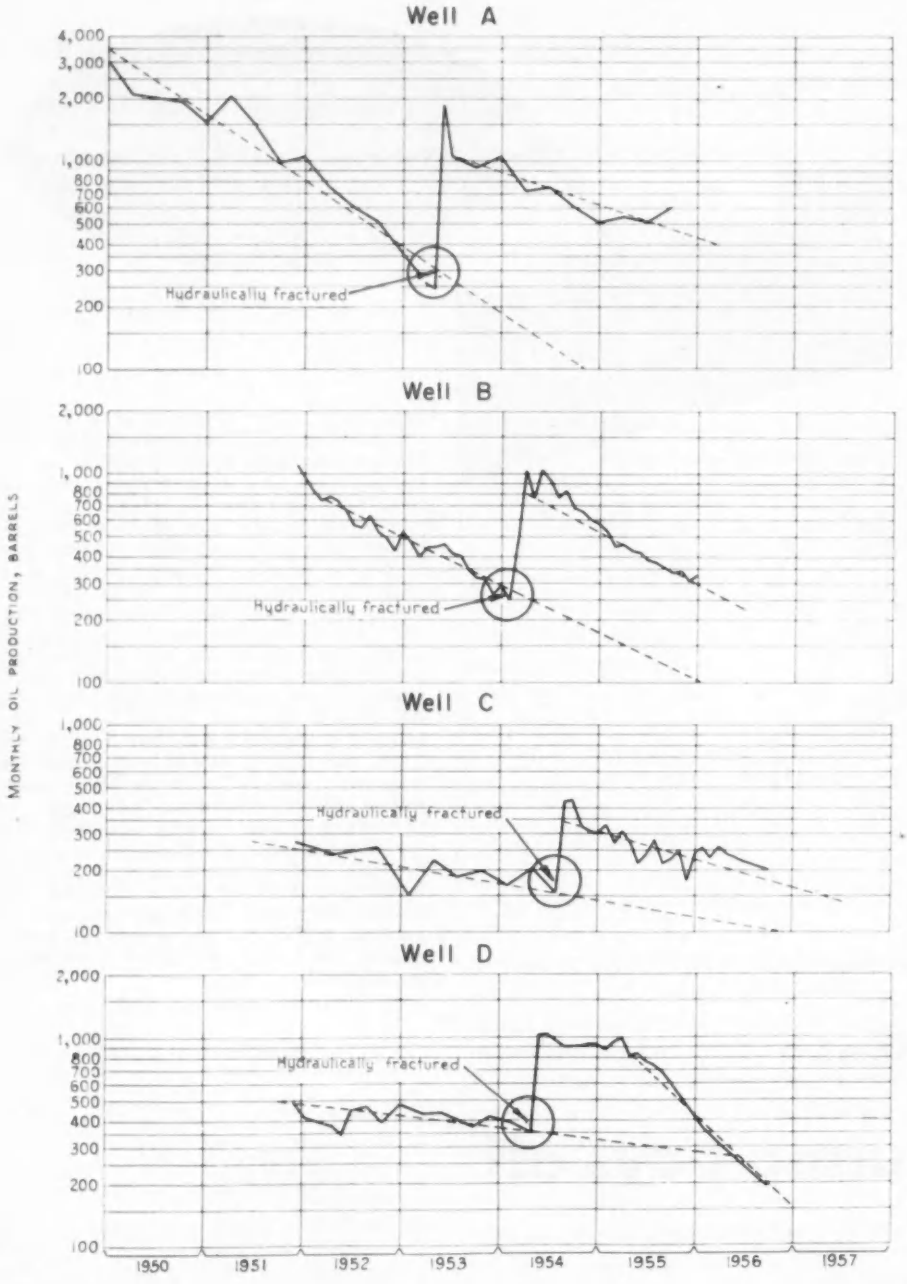

FIGURE 2—The rate of decline of individual wells before and after fracture treatments was compared individually for 101 Strawn wells. For 30 percent of the wells the rate of decline after treatment was less than before treatment (see Well A). Ultimate oil recovery will be increased from wells that have this type of performance. The rate of decline before and after treatment remained approximately the same for 41 percent of the wells. The curves are approximately parallel (see Well B). Again, additional oil is being recovered. The rate of decline was slightly greater than before fracture for 24 percent of the wells. However, the decline curves intersect at a point below the estimated economic limit of 3 barrels of oil per day (see Well C). Therefore, ultimate recovery of oil from these wells will be greater because of the treatments. Five percent of the wells had rates of decline after fracture, that were considerably greater than before treatment (see Well D). Although the decline curves intersect above the estimated economic limit, the Bureau estimates that the ultimate oil recovery is approximately the same. Therefore, considerable profit will be realized by consequent reduction of operation costs when the oil is recovered in a much shorter time. Study of the individual production decline curves has shown that in 71 percent of the wells the rate of decline after treatment approximately equaled or was less than the rate of decline before treatment. There can be little doubt that ultimate oil recovery will be enhanced in the majority of wells because of hydraulic-fracture treatment.

reservoir energy had declined appreciably.

• The extent of the treatments studied was limited, and none could be considered exceptionally large. Results indicated larger treatments generally will result in a large increase in production rate.

• Results obtained in treating thin formations as compared with thick formations indicated that better results could be obtained from thick formations by isolating and treating separate intervals of the productive zone.

• Wells shot with nitroglycerin did not respond to hydraulic-fracture treatment as well as those completed by other means.

Results from wells that had two or more treatments indicate that the production rate is stimulated by a second treatment. The increase from the second treatment usually will not be as large as that from the first. The decline rate of production normally will be less after a second and larger treatment than after the first one.

Hydraulic fracturing to stimulate production from low-productivity wells was developed by Stanolind Oil & Gas Company (now Pan American Petroleum Corp.) The process was first applied commercially in the North Texas area in 1949.

The increased number of treatments being used indicates acceptance of the process by industry. Initial benefits are recognized readily, but questions about the long-range effects of the treatment remain to be answered. One is whether ultimate oil recovery is increased by treatment or whether oil is only being recovered at a faster rate.

Treatment sizes and injection rates have varied. Also, different fluids have been used. These variations have created the problem of determining what combination is best for a particular well. Theoretical work, laboratory studies and field tests have been used. The questions, to a great extent, are unanswered because hydraulic fracturing still is relatively new. Final answers must be based on results from field applications.

This article presents the results of a study by the Bureau of Mines of hydraulic-fracture treatments of wells completed in the Strawn formation in North Texas. It concerns the effect of those treatments on the ultimate recovery of oil. A secondary objective was to determine the effect of various factors on results obtained from treating these wells.

Procedure. The study was confined

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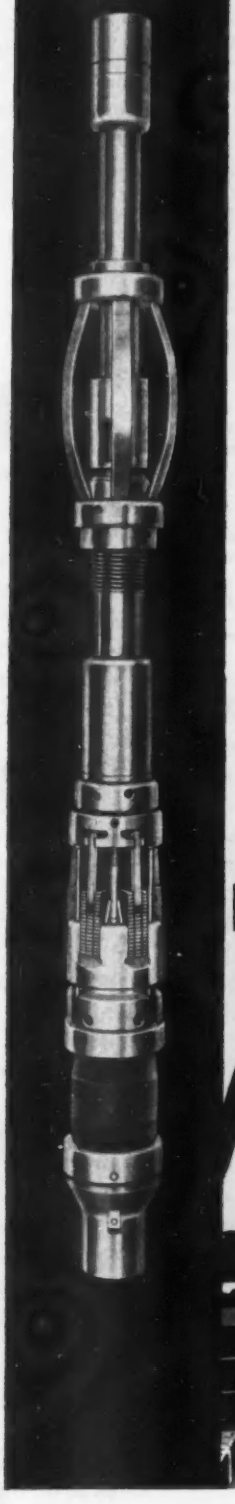

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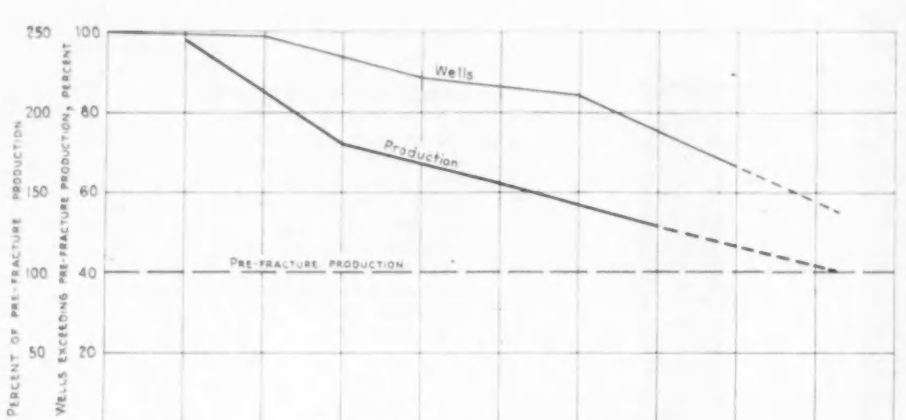


FIGURE 3—Data pertaining to 69 Strawn wells were used to plot these two curves. The production curve was obtained by plotting the total monthly production after fracture treatment, expressed as a percent of the total prefracture production, against time in months after treatment. This curve indicates that the production rate did not decline to the pretreatment level until approximately 30 months after treatment. Thus, increases in production rate as a result of the treatments were sustained gains. The wells curve shows the relationship between the number of wells whose production rates exceed those of pretreatment and time. This curve indicates that, by the time the total monthly production from the 69 wells had declined to the pretreatment level, the production rate of approximately 55 percent of the wells was greater than before treatment.

to an analysis of successful hydraulic-fracture treatments since failures would have no noticeable effect on ultimate recovery. Treatments were considered successful when the rate of oil production was increased enough to pay out the cost of treating the well and to realize a profit.

To ascertain treatment effects on ultimate recovery of oil, the study was limited to wells which had enough oil-production history to indicate the production-decline rate, both before and after treatment. These included wells from which the production rate had reached an economic limit as well as those producing at a high rate.

Comparison of the production-decline after treatment with the extrapolated decline curve based on production of the well before fracture treatment determined treatment effect on ultimate recovery and on rate of recovery. This comparison was made for each well and for various groups of wells as a composite.

Because of the erratic nature of daily and monthly production from oil wells studied, it was best to have a monthly production figure that would represent an average rate for the well at any specific period before and after treatment. So the average production rate of a six-month increment was selected. The average production rate was determined for each six-month period before and after treatment and, in this report it will be called "monthly production" during a specific period. The average production rate was used to minimize errors resulting from using well tests instead of measured monthly production for some wells. Also, the average value was used to avoid the erroneous results that can be obtained by using only one month's production before and after treatment. This method minimizes the effect of flush production common after treatment.

A secondary objective was to investigate the effect that some treatment and reservoir characteristics had on the results. Information on these characteristics was tabulated so that any trends that developed (as a result of changes in characteristics) could be detected.

Oil recovery from Strawn wells. The Strawn formation is oil-productive in many fields throughout North Texas. Sands vary in thickness and lithology and usually have low permeabilities. The Strawn generally responds more favorably to hydraulic fracturing than other oil-productive formations in the area.

Figure 1 (Page 155) shows the composite oil production history of 69 wells producing from the Strawn formation. These wells are examples from 18 fields in Archer, Clay, Cooke, Jack and Montague counties, Texas.

Graphic calculations show that about 484,200 barrels of additional oil was recovered from the 69 wells (Figure 1) during the 24 months after fracture treatment. This is an average increase of about 7,000 barrels of additional oil per well.

Figure 2 (Page 156) shows examples of the decline rate of individual wells before and after fracture treatment. A total of 101 Strawn wells were compared.

The production histories of the 69 Strawn wells (data from these wells were used to plot Figure 3) indicate the production rate for many of the wells after treatment was about the same as that about three years before treatment. The average number of months before treatment, when the monthly production approximately equaled that during the first six months after treatment, was determined. The results (when combined with decline rate that has been discussed) may be useful when predicting production rates following treatment and in estimating the additional oil that may be recovered from fracturing.

The production rate following treatment for 19 percent of the wells equaled that for the wells 13 to 24 months before treatment; for 55 percent of the wells, it was 25 to 42 months (average time for the initial 74 percent: 30 months). The 42 months category consisted of old wells wherein the decline rate was low. Others were relatively new wells, where the increase in production rate was large.

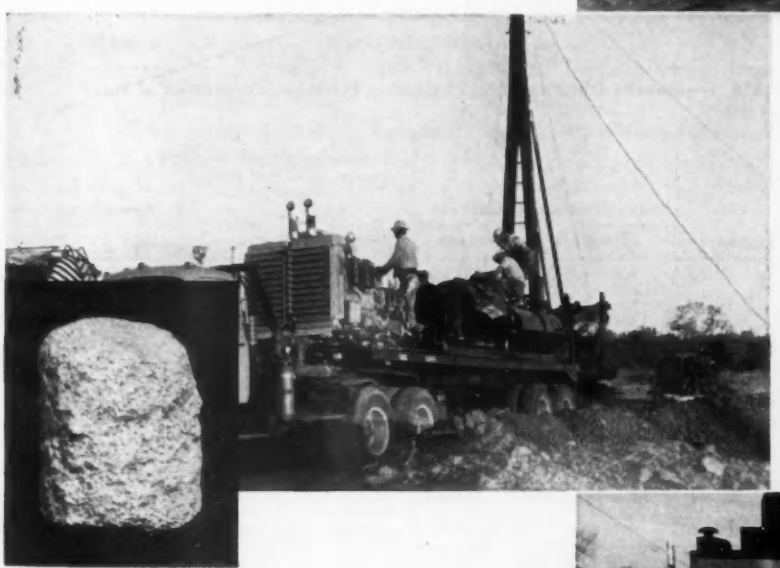
From this analysis, the average rate of production after treatment will be approximately the same as that 30 months before treatment. Coupling this conclusion with the fact that the slope of the decline curve before and after treatment is approximately parallel, the additional oil recovered will be approximately the same as that recovered 30 months before treatment.

Effects of treatment and reservoir characteristics. A secondary objective of the study was to determine the effects of various factors on successful treatment of a well by hydraulic fracturing. If the effect of formation thicknesses and permeabilities, state of depletion of the reservoir, various volumes of fluid and sand and different injection rates could be analyzed individually, it would be possible to select an optimum treatment fluid

DOWELL

BARBER COUNTY, KANSAS:
Although only slightly soluble in acid, the Mississippian chat formation responds well to Acid Petrofrac. Typical treatment: 1000 gallons fluid and 1000 pounds sand per foot of perforation, injected at 30 bpm. Results on gas wells are often ten times drill stem test.

YOUNG COUNTY, NORTH TEXAS:
Frac Acid usually obtains good results in the Caddo lime formation. Treatment example: 10,000 gallons 10 per cent thickened acid and 10,000 pounds sand, preceded by 500-gallon spearhead of Mud Acid. Treating material injected down casing at average rate of 33 bpm at 2200 psi maximum.



LINCOLN PARISH, NORTH LOUISIANA:
Stratafrac is often used in the Hosston formation with excellent results. It is designed to clean up fast and to suspend sand well at high temperatures. Recent treatment example: A new well was treated with 8500 gallons acid-kerosene emulsion, 2000 gallons low-surface-tension acid and 12,000 pounds sand. Pressures ranged from 4000 psi minimum to 6200 psi maximum. After treatment, initial open flow was 4100 mcfpd.

ECTOR COUNTY, WEST TEXAS:
In the Goldsmith Clearfork formation of the Permian Basin, Duofrac is frequently the answer to difficult production problems. A recent example: Before treatment the well would not produce. Dowell used a four-stage treatment — (1) 500 gallon spearhead of Mud Acid, (2) 10,000 gallons fresh water with de-emulsifying agent, (3) 25,000 gallons 7½ per cent acid with de-emulsifying agent and 25,000 pounds sand, and (4) 10,000 gallons fresh water with de-emulsifying agent as a flush. Potential after 35 days was 360 bopd. After 95 days, 273 bopd.

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About the Authors

Garland

Elliott

Thomas M. Garland, graduated in 1950 from Texas Technological College with a B.S. degree in petroleum engineering. He was employed as an engineer trainee for Stanolind Oil & Gas Co. in West Texas and a valuation engineer with the Internal Revenue Service in Dallas and Wichita, Kans., before joining the U. S. Bureau of Mines in 1955 as a petroleum research engineer in Wichita Falls, Texas.

William C. Elliott, Jr., was graduated from the University of Oklahoma with a B.S. degree in petroleum engineering. He joined the U. S. Bureau of Mines in June, 1949, in Dallas, where he worked as a petroleum engineer and was assistant chief of that office when transferred to Wichita Falls, Texas, in November, 1957. He is now chief of the Wichita Falls field office (petroleum) of the Bureau of Mines.

volume and an optimum injection rate. (Analysis of data was confined to 65 Strawn wells because there was more information about this group.)

Treatment volumes. Correlation of treatment size to results was attempted by using both the total fluid volume employed and the fluid volume per foot of pay treated. No specific correlations could be made for individual wells because equally successful results often were obtained with different size treatments. Results obtained by several similar treatments were grouped, and averages were determined for those groups. Resulting increases in production rates are listed by net barrels and percent in Table 1A.

Exceptionally good increases were obtained with small-volume treatments. These treatments (600 to 1,000 gallons of fluid) were responsible for an average increase of 517 barrels per month.

Treatment results also were compared on the basis of specific volume of fluid injected per foot of formation treated (Table 1B). Increases ranged from 98 percent for wells treated with average volumes of 42 gallons per foot of pay to 257 percent for wells treated with average volumes of 247 gallons per foot of pay.

Exceptionally good increases in net barrels were obtained with small-volume treatments. This also was true in the previous comparison shown in Table 1A. Even though the percentage of increase for the small-volume group is the smallest, the increase in net barrels is next to the largest.

The group of wells subjected to small-volume treatments exhibited one characteristic different from the others: The rate of production before fracturing was greatest. These small-volume treatments were the first in the area and, to a great extent, were used on better wells. The successes of early treatments were responsible for expanding hydraulic fracturing. Later wells selected generally were not as prolific as the first wells treated. If the good results of the small treatments can be attributed to the fact that they were on the more prolific wells and are omitted in comparing results, both tables indicate progressively larger treatments obtained greater increases in production rates. Average effects of very large treatments cannot be determined since little information was available.

Thickness of formations. The oil productive sections of the Strawn formation range in thickness from 3 to 50 feet. In most treatments, no effort was made to selectively treat a particular segment of the thicker sections.

Formation thickness is one variable that could affect the treatment results. Therefore, results of 65 treatments were studied to see if production rate increases could be correlated with formation thickness.

Well data were tabulated according to the thicknesses of the oil productive sections. Average increases in production rates then were computed for the groups of wells producing from sections of varying thickness. The averages for the sections are

TABLE 1—Results Obtained From Injecting Different Quantities of Fluid

A (Gallons of fluid)

Number of Treatments	Size Treatment, Gallons		Average Monthly Production Per Well, Barrel		Average Increase	
	Range	Average	Before Treatment	After Treatment	Barrel	Percent
12	600—1,000	838	362	879	517	143
19	1,500—2,000	1,855	241	567	326	135
15	2,500—3,000	2,833	184	561	377	205
8	3,500—4,000	3,875	313	715	402	129
11	6,000—8,000	6,573	322	799	477	148

B (Gallons of fluid per foot of pay)

Number of Treatments	Size Treatment, Gallons		Average Monthly Production Per Well, Barrel		Average Increase	
	Range	Average	Before Treatment	After Treatment	Barrel	Percent
19	15—75	42	452	897	445	98
17	77—125	104	252	600	348	138
10	133—167	147	253	611	358	142
6	177—219	193	170	533	363	214
7	235—250	247	254	907	653	257

TABLE 2—Results Obtained by Treating Formations of Different Thicknesses

Number of Wells	Interval, Feet	Average, Feet	Average Monthly Production Per Well, Barrel		Average Increase	
			Before Treatment	After Treatment	Barrel	Percent
5	0—10	6.2	91	505	414	455
20	11—20	16.9	261	603	342	131
15	21—30	24.9	233	700	467	200
15	31—40	36.6	266	627	361	135
10	41—50	44.3	497	910	413	83

Thin zones should be isolated and treated separately . . .

listed in Table 2. Although increases were obtained from all groups, the best results came from the thinnest section. The average rate of oil production increased from 91 barrels a month before treatments to 505 barrels a month after treatments.

Treatments resulted in increased production rate of over 500 barrels a month for some individual wells in each of the five formation intervals. Also, there was an increase of less than 100 barrels a month for some wells in each of the intervals.

The successes in treating thin formations indicates that productive zones of thicker formations should be isolated and treated separately, if possible.

The relationship between the average production rate both after and before treatment is shown in Figure 4.

Treatments that fracture the productive formation (especially nitroglycerin or hydraulic fracture) affect subsequent hydraulic-fracture treatments. In areas where formations were fractured previously, reservoir energy generally is depleted to a greater extent than elsewhere.

Wells Shot With Nitroglycerin. Wells in the North Texas area previously shot with nitroglycerin did not, as a rule, respond to hydraulic-fracture treatment as well as those completed by other means.

Twenty-four of 65 Strawn wells were shot with nitroglycerin at original completion. Charges used ranged from 20 to 150 quarts, averaging 50 quarts. Generally, wells that were shot had a production history of 5 to 10 years before hydraulic fracturing.

The average production rate of these 24 wells was boosted from 241 barrels to 563 barrels a month as a result of hydraulic-fracture treatments. The average production rate of 41 wells (that had not been shot) was raised from 333 barrels a month to 804 barrels. Before treatment, the average oil-production rate of the latter wells was 92 barrels a month more than that of the "shot" wells. After treatment, this difference was increased to 241 barrels per month.

Fracturing results in low-productivity wells particularly illustrate the difference between the shot and unshot groups. At the time of treatment, 16 of the 65 wells each was producing less than 100 barrels per month. Five of the 16 had been shot at initial completion. The average rate of oil production from the five wells increased from 49 barrels to 201 barrels per month. The pre-hydraulic fracture average rate of production for the 11 wells that had not been shot increased from 63 barrels to 436 barrels per month. Fracture treatment resulted in individual production rate increases of over 400 percent for 8 of these 11 wells. Only 1 of the 5 "shot" wells showed a comparable increase.

Previous Treatment by Hydraulic Fracturing. Eleven of the 65 wells had been subjected to more than one treatment. Additional treatments were used to halt rapid production declines, to stimulate production, or both.

Before the first treatment, the average production rate from these wells was 199 barrels a month. After fracturing, the average was 711 barrels, an increase of 257 percent. Average production before the second treatment was 259 barrels a month. After treatment, the average was 474 barrels, an increase of 83 percent.

Results indicate that the increase for the second treatment usually will not be as large as that after the first treatment. However, the rate of production decline will generally be less after a second and larger treatment.

Many factors affect the results of a fracture treatment. The degree of success or failure of a treatment depends upon a combination of all variables common to the treatment and to the reservoir. However, since data used in this report were obtained from a large number of fields throughout the North Texas area, an evaluation of treatment results for this group of wells should be indicative of results that can be expected in the future.

ACKNOWLEDGMENT

This article is based on the U. S. Bureau of Mines Report of Investigation 5371, "Effects of Hydraulic Fracturing Upon Oil Recovery From the Strawn and Cisco Formations in North Texas," by T. M. Garland, W. C. Elliott, Jr., Pat Dolan and R. P. Dobyns. The work upon which that report was based was done under a cooperative agreement between the Bureau of Mines, U. S. Department of the Interior and the North Texas Oil & Gas Association.

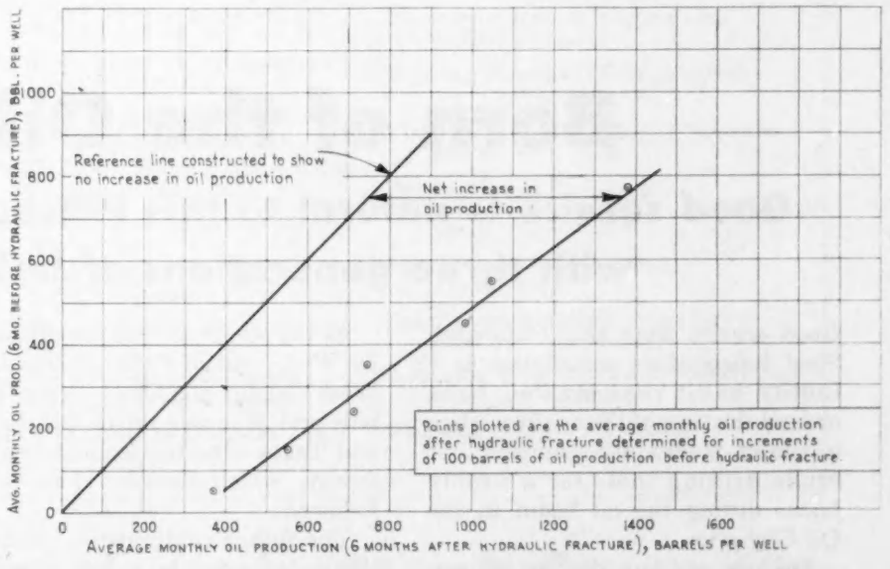
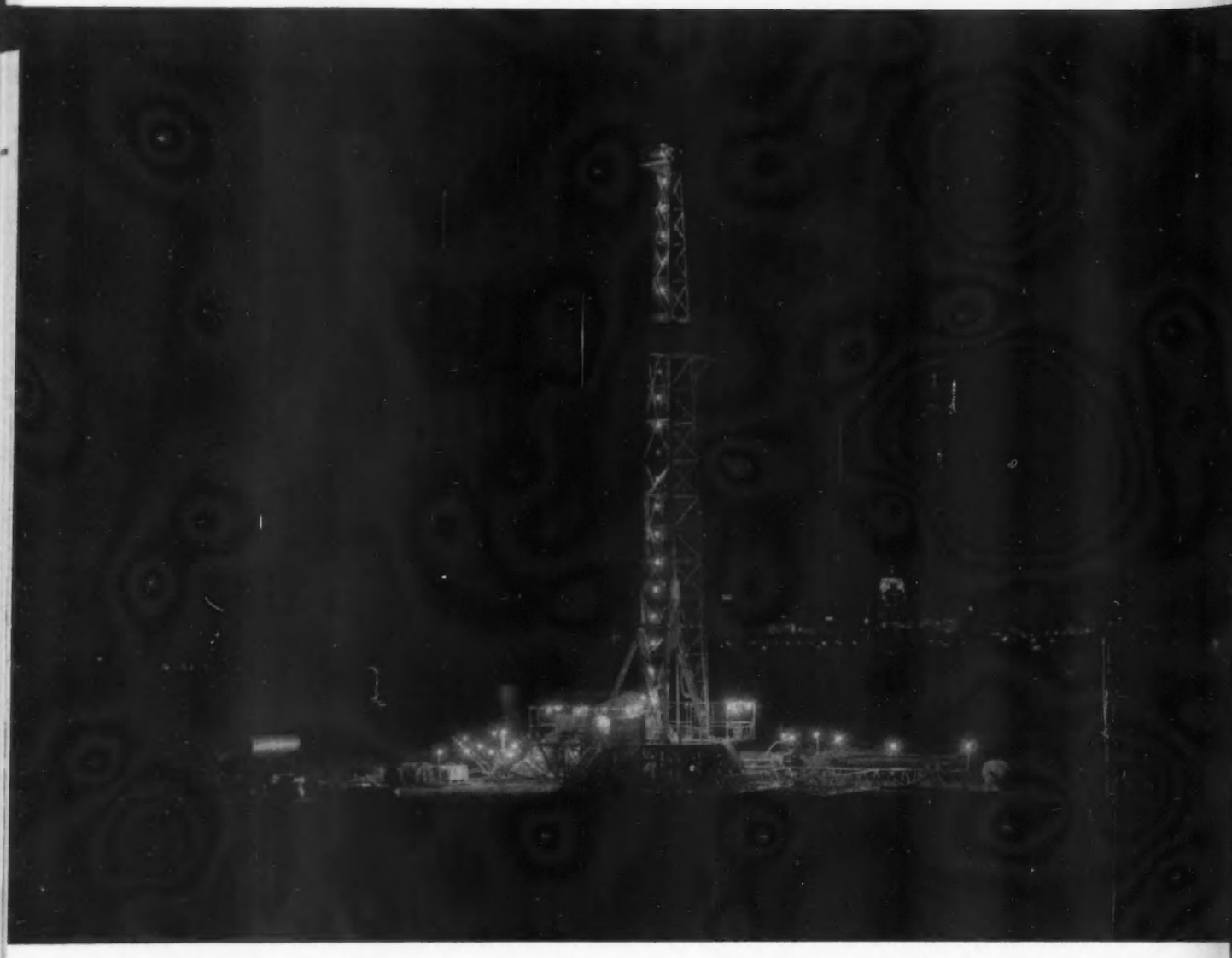


FIGURE 4.—Here is the relationship of oil production after hydraulic fracture to oil production before hydraulic fracture. The line on the left is a reference line indicating no increase in the rate of production. The other line was constructed by using the plotted points, which represent the average rate of production before and after treatment for the wells grouped within 100-barrel increments in the rate of production before treatment. The distance between these two lines represents the average increase in rate of production. It will be noted that the two lines diverge with increasing rates of production before fracture treatment. This indicates that wells with an initially high rate will have a larger increase after treatment than those with an initially low rate of production before treatment.



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At the rig Wayne G. Wallace, distributor's district manager, talks over Pittsburgh drill pipe performance with driller Clifford A. Funk. Daily contact like this enables distributor's field force of more than thirty men, plus another seventy in stores and offices to anticipate and furnish needed items promptly. Stores are linked with teletype system to provide maximum flexibility and service.

Following through on drill pipe order, Wayne Wallace makes sure that correct number of drill pipe lengths have tool joints flash welded to pipe as specified. Service such as this has built strong customer loyalty to his firm—even in distant lands. To Jamaica in the British West Indies, this distributor shipped a 7500-foot string of Pittsburgh 3½" Grade D Seamless drill pipe and other production items on a rush order.

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In the case of this particular distributor, the soundness of the founder's independent policy enabled the company to multiply its original store nine-fold. Now sons and grandsons operate two stores in New Mexico, three in Oklahoma, three in Texas and one in Cortez, Colorado; plus offices in Fort Worth, Dallas and Midland, Texas; Denver, Colorado; Tulsa and Oklahoma City, Oklahoma.

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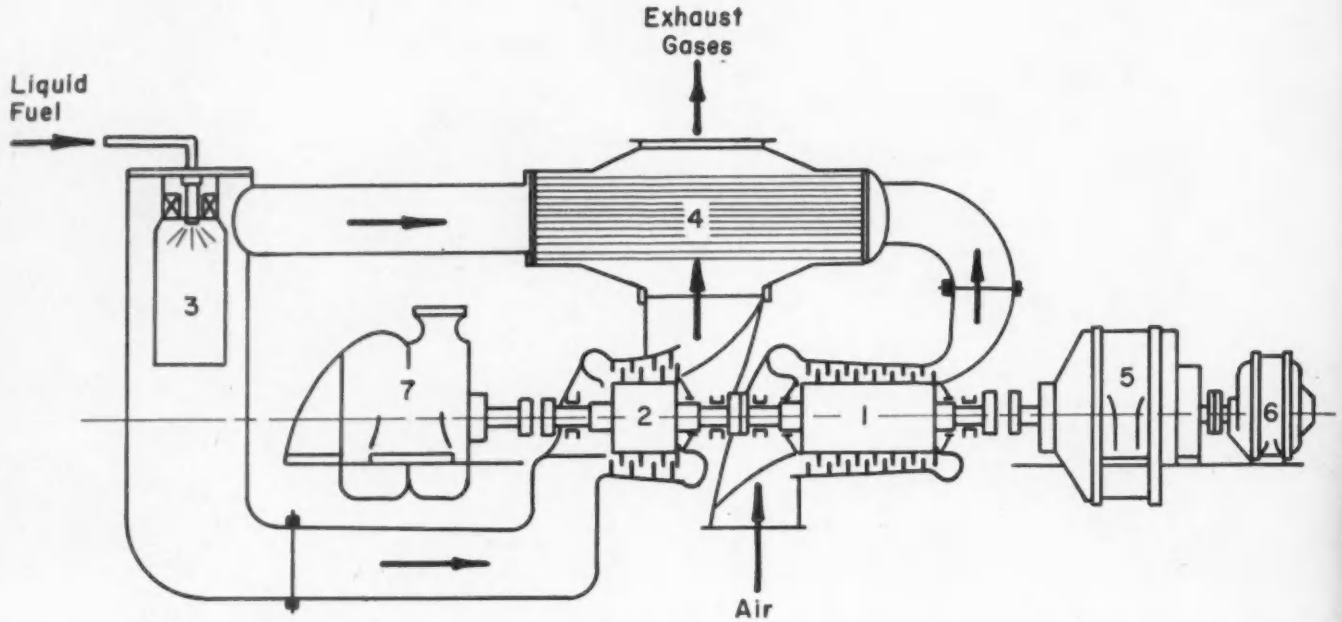

FIGURE 1—This is the Russian design of drive for heavy drilling rig intended for turbine and rotary drilling. (1) axial compressor; (2) gas turbine; (3) combustion chamber; (4) air heater; (5) generator; (6) blower; (7) pump centrifugal or impeller.

Russia claims . . .

Progress in gas turbo-electric drives for drilling rigs

New equipment expected to provide more powerful, efficient prime movers and to eventually replace Russian diesel rigs

A RECENT ARTICLE in a Soviet technical publication advises that Russia soon expects to produce compact turboelectric drive units for drilling rigs. These units will have a capacity of 300, 1,000 and 1,500 kwts, respectively, designed in basic parameters suitable for power drives of drilling rigs. Schematic designs of these drives appear in Figures 1 and 2.

A Russian inventors' team began work in 1951 on development of gas turboelectric drives for drilling rigs in hopes of effecting advantages over conventional diesel drives. Advantages seen in gas-driven rigs are:

• To get the power needed to drive the chief mechanisms of the drilling rig in two (or, if possible, one) compact units connected with operating mechanisms by electromechanical transmissions, thus simplifying the de-

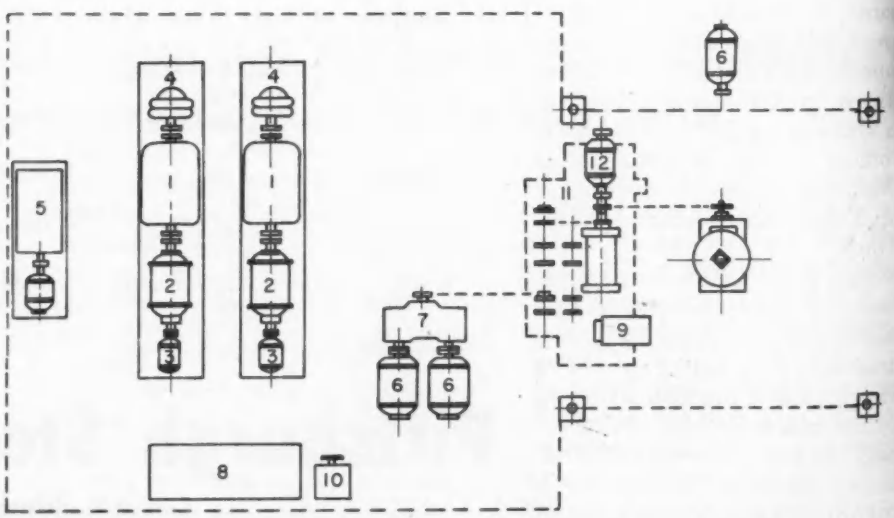

FIGURE 2—Model diagram of grouping and layout of equipment of Russia's gasturbo-electric drive on a drilling rig. (1) gaso-turbine unit; (2) generator; (3) blower; (4) pump centrifugal or impeller; (5) diesel generator for internal needs and starting gaso-turbine units; (6) drilling electric motors; (7) two-motor reducing gear; (8) distributing panel; (9) control panel; (10) starter rheostat for starting turbines; (11) drilling hoist; (12) additional brake.

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sign of the power unit and facilitating the assembly of equipment.

- The use of various kinds of cheap fuel, either liquid or gas. Natural gas is, of course, especially convenient in newly-developed oil districts, and its use for this purpose is stressed.
- The use of heat of exhaust gases for drilling and related rig purposes. The possibility of heating steam with exhaust gases was mentioned.
- To make possible the use and standardization of electrically-driven drilling rigs even in non-electrified districts.
- The use of gas turbine, if needed, as a direct drive for axial-type pumps.
- To make available relatively large engine power reserves.
- To allow drilling in non-electrified districts with electrodrills fed from generators of the power unit (see Russia Tests Wireline Electrodrill, WORLD OIL, May 1958, Page 124). This is important for drilling gas wells with heavily weighted muds under high pressure, which reduces the effectiveness of turbine drilling.

At least two types of mechanisms are envisioned for the new system. Solutions to different drilling problems can be varied depending on the class and purpose of the drilling rigs. Figures 1 and 2 illustrate designs of one such drive for a heavy drilling rig. This drive can be used for both turbine and rotary drilling.

Turbine drilling. In this adaptation, one or two pumps are operated, depending on the type of turbodrill, its working conditions and drilling depth. Connected in parallel or series, each pump is rotated by its own gas turbine unit. The most efficient conditions for the pressure system and turbodrill are obtained by adjustment of the drive unit's rotating speed. During lowering and raising of the drilling tool, electric motors of the winch get power fed from jointly operating synchronic generators.

Rotary drilling. In the more conventional adaptation, one of the gas turbine units rotates its pump and the generator feeding the rotor's electric motor. With pump and generator switched off, the second gas turbine unit is used for supercharging, in the capacity of a preconnected gas turbine compressor. Thus, the power of the first unit is doubled with simultaneous increase of total efficiency.

Russians say that other drive designs also are possible with electromechanical transmissions to all mechanisms, including pumps (either centrifugal or reciprocating), with either one or more units. However, development and field testing of such gas turbine drives have been long delayed due to lack of suitable designs of gas turbine units of necessary capacity. However, the report stressed that practical application of the principles and designs noted in this article were expected to reach fruition soon, with necessary hardware now in the production stage.

If this equipment proves successful, it will represent a step forward in providing more efficient power drives for Russia's drilling rigs. It is expected that these new units will replace many Russian diesels now standard in the nation's drilling rigs.

According to the latest reports, these diesel drives have many disadvantages, including:

- Low capacity for operation with rehandling.
- Lack of reversibility.
- Cumbersome intermediate transmissions.
- Difficulties in assembling and transporting.
- A short term of service (about 2,000 hours).
- High fuel consumption.
- A high noise and vibration level.

—The End

About the Author

Harold J. Reedy attended the University of Oklahoma and received a degree in geological engineering in 1947. He joined the British American Oil Producing Co. in 1952 and is presently division geologist for the company's Central division in Oklahoma City. He has had wide geological experience in the Mid-Continent area, having done subsurface geological work in West Texas, North Texas, Kansas, Oklahoma and North Dakota.

UNCONTROLLED DIRECTIONAL DRILLING

Continued from Page 118

this the assumption is made that bit rotation to the right caused the variation.

The maximum hole deviation occurred in all wells below 10,000 feet, and in all wells this is in the Springer shale. The migration of the hole back toward the surface location is due to dip reversal below an intraformational fault zone in wells on the northeast flank of the deep structure, and the hole begins to move updip in the opposite direction.

The hole deviation after reaching a maximum angle begins to move back toward the vertical below the basal part of the Springer in wells on the southwest flanks. These wells continue to show some hole deviation and the horizontal displacement continues to increase to total depth. As the hole becomes deeper, the result of a combination of factors affecting the drift of the hole updip is a decrease of the angle of inclination from a maximum to a lesser degree but still enough to continue the horizontal displacement away from the surface location if the dip remains in the same direction.

Plot of horizontal displacement. The horizontal projections of the deep wells have a pattern that falls into two categories:

1. A horizontal displacement in one direction with a reversal and drift in the opposite direction.
2. A horizontal displacement in the same direction.

Figure 3 is an illustration of a typical well in each of these categories. Experience has shown that when a bottom hole location falls on or southwest of the Pre-Pennsylvania axis, the horizontal displacement is in the same direction similar to illustration 2 of

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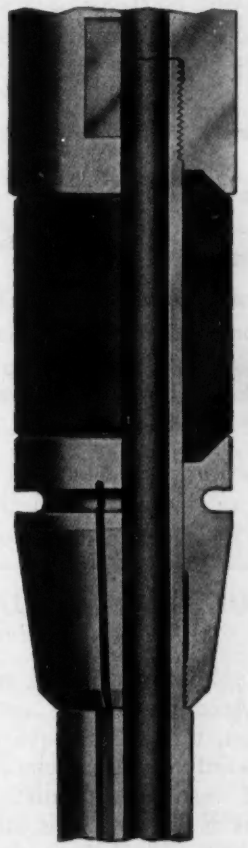

The unique split cone design is internally wickered to provide a positive initial hold-down with a compression packoff rubber.

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Pin here when tool enters tubing
Travel of pin to unseat and lower tool
Pin here before starting in tubing
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Pin travels down length of pick-up when making connections
Pin here when rods are picked up to set. Tool is then lowered to set position

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Figure 3. A well northeast of this axis will have a displacement pattern similar to illustration 1 of Figure 3.

Development. Since completion of Harrison 2 well Feb. 14, 1956, six gas wells have been completed. One dry hole has been drilled, and six wells currently are drilling.

A study of the data obtained from the directional surveys of the wells drilled at Carter-Knox and the subsurface geology leads to the following conclusions:

- The horizontal displacement of a well bore in areas of steep dip will be in an updip direction.
- The direction of horizontal displacement will be left of the actual updip direction.
- Greater angles of hole deviation (inclination) can be obtained in soft formations than in hard formations.
- The angle of hole deviation can be increased by an increase in weight, unless the angle of deviation is near the angle of dip.
- Increase in speed of rotation will reduce the angle of deviation.

The practice of uncontrolled directional drilling has been successful at Carter-Knox. It has resulted in reducing the drilling costs by hundreds of thousands of dollars though no estimate of actual savings has been made.

The wide spacing at Knox provides ample room for a sizable target area to be specified which is easy to hit. Smaller well spacing would reduce the size of a target area which could be used. This type of drilling could be used successfully in drilling spaced units as small as 40 acres. Even on 10-acre spacing, an allowance for horizontal displacement could be made which would result in a greater penetration rate than trying to drill a straight hole in the center of the 10 acres. —**The End**

SUBSURFACE OUACHITA STRUCTURAL BELT

Continued from Page 142

sheared phyllites, slates and metaquartzites. According to the author's interpretation, these rocks have been thrust westward over the unmetamorphosed and very weakly metamorphosed rocks of the belt. This contact is a major structural discontinuity. Named the Luling overthrust front from the area where these highly sheared rocks were first penetrated by the drill, it may be analogous to the Blue Ridge front of the Appalachian area. The Luling overthrust front is not, in any sense, a simple overthrust. More likely, it is a complex zone of multiple overthrusts and strongly overturned folds, possibly even with development of nappes.

In south-central Texas, there is a narrow zone in the sub-crops south of the Luling front which is distinguished by intensely deformed dark slates, altered greenstones and partly mylonitized granitic rocks. The extreme deformation and the mylonitic rocks suggest that this zone may be the sole along which the Luling overthrust front advanced.

Immediately west of the Llano uplift there is evidence to suggest that lower Paleozoic Ouachita facies rocks have been thrust northwestward (possibly with some tear faulting) over sedimentary rocks of the Kerr basin. West of this area there appears to be a major re-entrant in the front of the belt (Figure 1). Farther west, in the Kinney-Val Verde-Terrell counties area, highly-sheared phyllites, slates, marbles and metaquartzites appear to have been thrust northward over the frontal zones of the belt.

Atokan beds north of the Luling front in Kinney County contain metamorphic rock fragments evidently derived from the highly-sheared terrain. Unmetamorphosed Ouachita facies (Marathon facies) rocks of the frontal zone of the structural belt are exposed to the west in the Marathon salient. There, the Ouachita belt is marked by a great frontal thrust (the Dugout Creek overthrust) with a displacement in excess of eight miles. This overthrust has been mapped in the Marathon basin. Most probably, it extends southeastward through Terrell County into Val Verde County and is overridden by the Luling front.

Width of the belt. Well data shows that the Ouachita structural belt in Texas extends for a length of more than 900 miles and for a width of 50 or 60 miles. The width of the belt disclosed by drilling is no more than the western and northern edge of a major orogenic system. What lies to the east and south beyond the downdip limit of well control is a matter for speculation.

Cataclastically altered granitic rocks found in wells in Medina County and a fragment of sheared muscovite granite (from a conglomerate overlying a sequence of sheared greenstones and slate) from a well in Maverick County show that granite intrusions occur within the Ouachita belt to the south. These granites were emplaced before or during the deformation.

In the author's opinion, there is reason to suspect that the basement of part of the Gulf Coastal Plain may be a Ouachita piedmont similar to the Applachian piedmont.

Exploration. An understanding of Ouachita structural belt geology is fundamental to an accurate picture of the structure of the North American continent. Such an understanding also is important in evaluating oil and gas possibilities of the belt. The relation of folded and thrust-faulted rocks of the frontal zones of the belt to the foreland shelf and foreland basin facies rocks lying adjacent to the structural belt is of particular interest to exploration geologists.

Specifically, the eastern edge of the Fort Worth basin and the southern parts of the Kerr and Val Verde basins deserve critical examination. Rocks of Ouachita facies do not offer much encouragement to oil seekers. However, foreland facies rocks involved in and overridden by the frontal structures of the Ouachita belt may contain commercial deposits of oil and gas.

Frontal structures of the Ouachita belt in the Fort Worth, Kerr and Val Verde Basins are truly terra incognita. From Grayson County to Brewster County there are less than a dozen really significant deep tests.

There are a number of reasons why exploration of these areas has lagged. Deep wells are required to test lower Paleozoic prospects, and difficult drilling conditions result in high costs. Structural complexity and lack of stratigraphic data mean that there must be a good deal of educated guessing in prospect evaluation.

ACKNOWLEDGMENT

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Afghanistan needs and hopes for oil production. The remote Asian country adjoins the petroleum producing countries of Iran, Pakistan and U.S.S.R.

Active oil exploration is proceeding in Afghanistan

U. S. and Russia compete strongly to assist oil development in ancient, isolated Asian nation

ASIA'S ANCIENT, isolated Afghanistan in the past year has been the scene of significant petroleum developments. Important events have included the drafting of proposed petroleum legislation, vigorous reconnaissance petroleum exploration, and stiff competition between the U. S. and Soviet governments to help Afghanistan develop its natural resources.

Throughout history, Afghanistan has been held back because of its extreme isolation and repeated invasions from outside. Attacks by the ancient Persians and medieval Mongols were followed by intermittent disputes with the British in India. In addition, there have been many disputes with the Russians.

As a result, Afghans generally are very suspicious of foreigners, and the country remains centuries behind the times. Modern roads, railroads, and electric power are almost unknown. Nothing could be more symbolic of the isolation of Afghanistan than the fortification and constant watch over the Khyber Pass that Kipling made famous in his writings.

In 1938 Island Exploration Company, an American firm, relinquished a concession covering an area in Afghanistan between the Hindu Kush Mountains and the Russian frontier. Extensive surface geological work indicated a favorable environment for oil accumulation. But it was concluded that costs to move any oil found to Free World markets would be prohibitive. Particularly discouraging was a stipulation by the Afghan government that any pipe line would have to be built through Iran, not through India.

A dispute with India persisted at the time. Border difficulties with Pakistan have yet to be entirely resolved. Such troubles aggravate the natural isolation of Afghanistan. Other than Pakistan, the only trade routes thus far developed in and out of Afghanistan are through Russia.

In 1950 the Afghans sought technical help to develop possible petroleum sources through a group of French technicians. The Russian government objected to reconnaissance in border and near-border areas by any group from a NATO country. Russia's complaint was based on a 1929 treaty with Afghanistan. It provided that neither nation would contract with a foreign party to engage in activity which either nation considered contrary to its own interests. Afghanistan rejected Russia's complaint, for the record anyway, but ejected the French group.

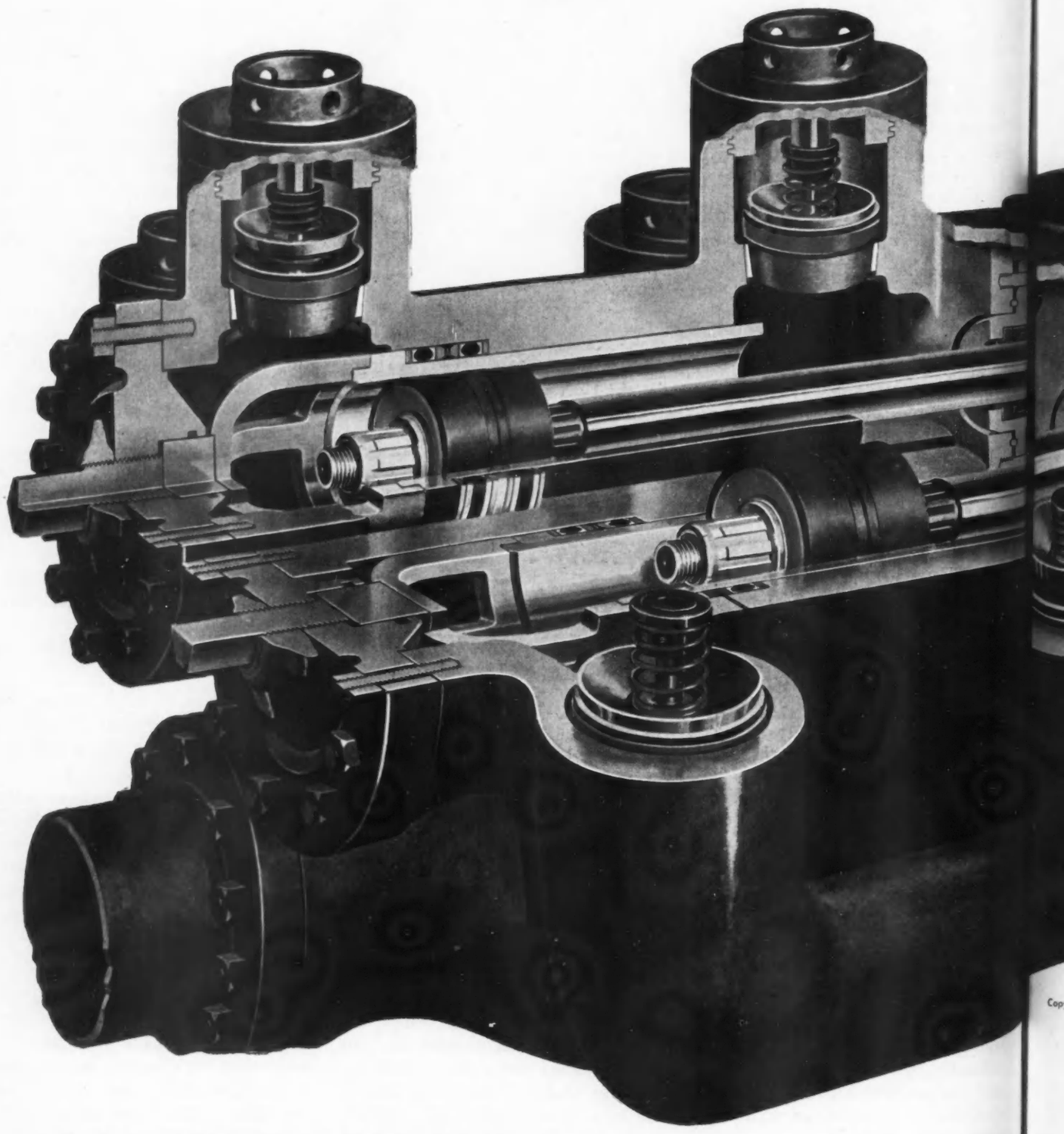
In its place Swedish technicians were brought in to search for oil in northern Afghanistan. (Sweden is not a NATO country.)

By 1956 drilling operations were commenced near Sar-I-Pul ("Head of the Bridge"). The first well encountered shows of oil and gas, but had crooked-hole difficulties. The second well was being drilled during the spring of 1958, and shows of oil and gas were reported from it also.

On January 7, 1958, an agreement was signed between the Afghan Ministry of Mines and Industries and the Soviet TCGNO-Export company for oil exploration in part of northern Afghanistan. Czech technicians had arrived in Afghanistan by the spring of 1958.

The U. S. government is making strenuous efforts to assist Afghanistan in its modernization and development efforts. Its primary difficulty is that of interesting private U. S. firms to invest in Afghanistan. So far, development funds have come in the form

The "Inside Story" of the Heart



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...of Your Rig ..... by MISSION

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WE MADE THIS cutaway view of a mud pump so you can see just where the vital fluid-end parts fit and why they are essential to correct operation. Your mud pump is one of the hardest working parts of your rig. Forces on these fluid-end parts are staggering. For example, pistons and rods may be subjected to forces of more than 100,000 pounds. These forces may be multiplied by shock loading at times, and they are completely reversed at least once every second. When you remember that mud may contain abrasive sand to cut metal parts; corrosive chemicals to pit them, and oil to attack rubber, it seems obvious that only the best pump parts stand a chance.

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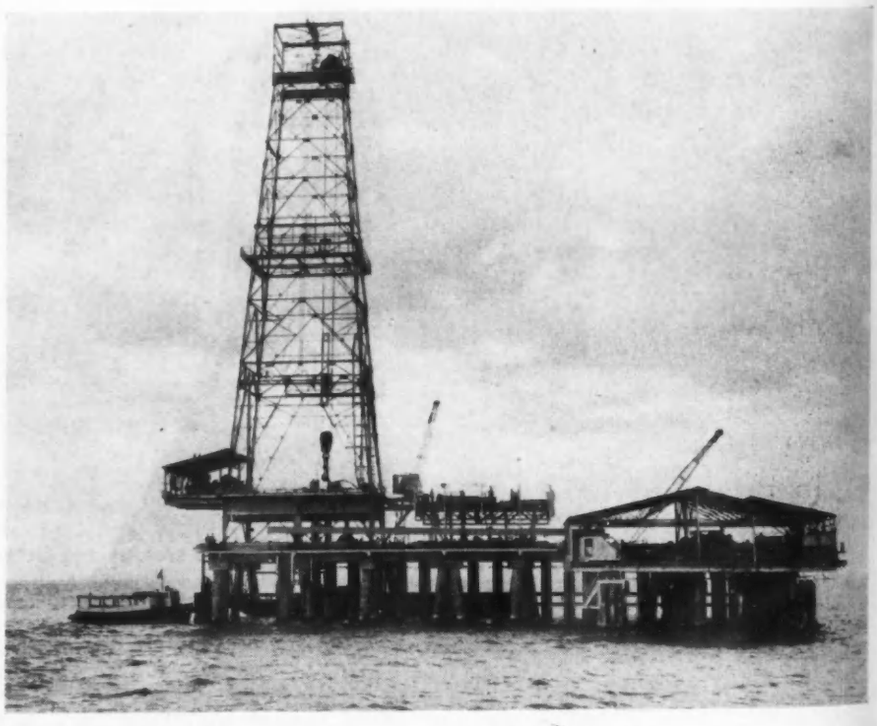
of U. S. grants, and loans from the Export-Import bank.

A U. S. firm at the middle of 1958 was engaged in an aerial photographic survey of Afghan territory, excluding the strip along the Russian border. Photogeologic studies were expected to follow completion of the work, which was part of a general U. S. program to assist Afghanistan in civil aviation. Morrison-Knudsen has completed preliminary studies in southern Afghanistan near Gardez, and in Seistan in the extreme southwest. Both areas are said to have petroleum possibilities. Morrison-Knudsen's primary activity in Afghanistan is construction of two flood-control and irrigation dams in the Helmand River Valley, at Arghandab and Kajakai, respectively.

Inability to attract private Free World capital to Afghanistan has prompted its government to draft suitable petroleum legislation. Through U. S. Government auspices, Dr. Ralph Miller, staff research geologist of the U. S. Geological Survey, visited Afghanistan early in 1958, returned to the U. S. to draft proposed legislation, and went back again to Afghanistan during the spring to further his suggestions. Dr. Miller has also proposed training of qualified Afghans in the petroleum industry through work in other countries. Iraq Petroleum Company and Arabian American Oil Company have indicated some interest in assisting the training of some Afghan technicians.

Afghanistan is in extreme need of domestic fuel sources of all kinds. Limited timber stands in remote parts of the country constitute about the only reserves of fuel.

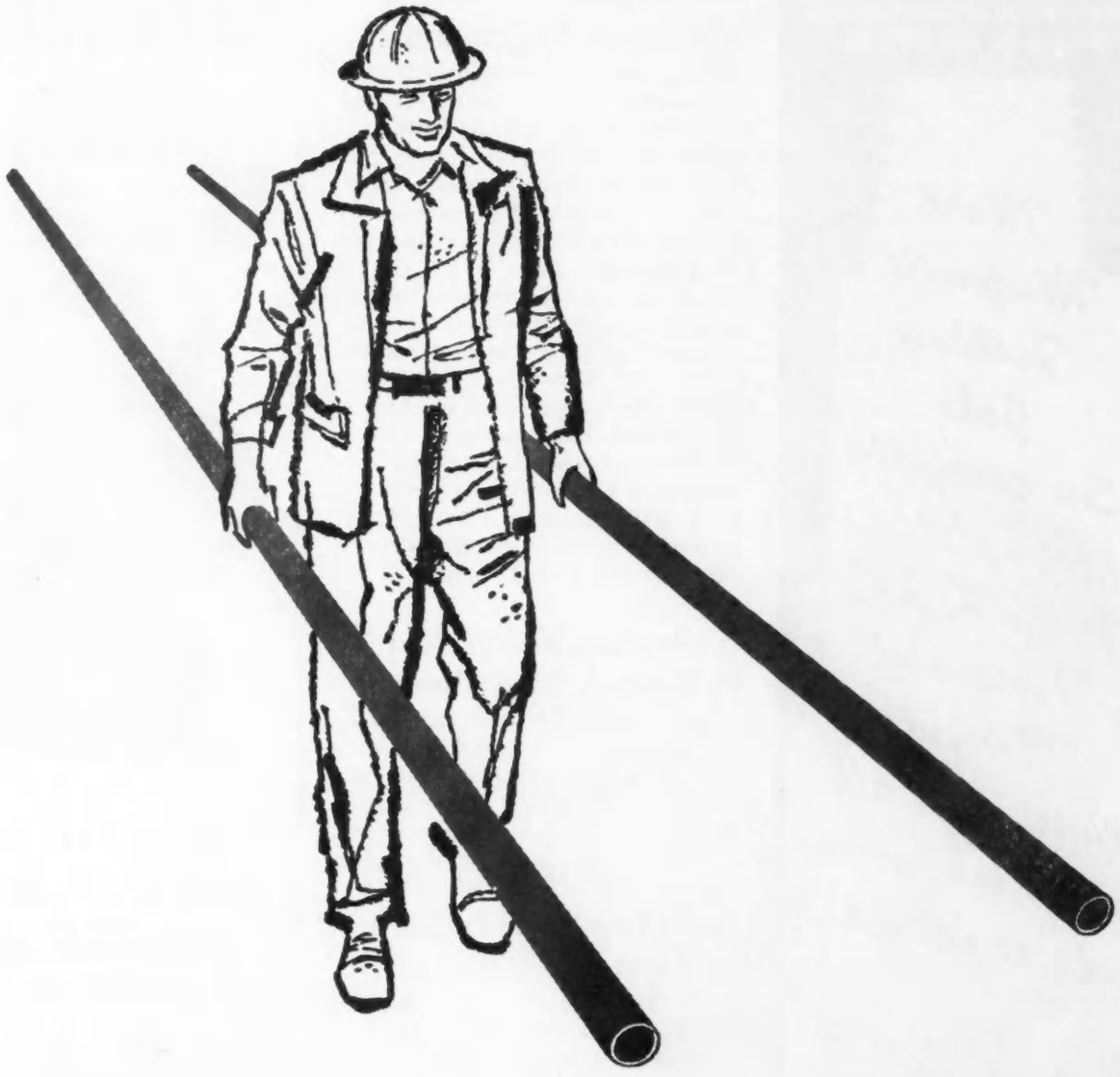
In the meantime, the Russians are active in marketing of petroleum products. Asphalt is trucked in and stored at Russian-built facilities in Kabul, Pul-I-Kumri, and other urban areas. A program is under way to pave the streets of Kabul, the capital, which are being surfaced with Russian asphalt. —**The End**



Multiple Well Platform Active in Trinidad's Gulf

Texaco Trinidad, Inc., has here joined in the active offshore development in the Gulf of Paria, off the coasts of Trinidad and Venezuela. This stationary multiple well platform, designed for offshore directional drilling, is in the Trinidad part of the gulf. It mounts a derrick that drills six holes from one position, then skids itself ahead to drill another six holes.

The 52 by 157 foot platform is designed for drilling 36 wells, and is easily expanded to handle 72 wells. It is supported on 144-foot long prestressed concrete cylinder piles, and stands in 68 feet of water.



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Iraq Is Reported Seeking Additional Oil Operators

The Iraq government has reportedly asked Iraq Petroleum Company to cede some of the area under concession to the company and its affiliates. They hold all of the nation's territory with the exception of the small Chia Surkh concession held by Khanaqin Oil Company Ltd.

Relinquished areas would assumedly be put up for competitive bids by companies interested in exploring for oil in Iraq. The nation would thus follow the example of Saudi Arabia, Kuwait and Iran, newly opened to additional companies through bids outside the Consortium area of South Iran and to a Japanese company granted an offshore concession in the Saudi Arabia-Kuwait Neutral Zone.

Tunisia Concession Held By Rimrock International

Rimrock International and its Italian subsidiary Societa Olii Minerali have acquired a 620 square-mile concession in Tunisia. It covers part of Cape Bon, Djerba and Kerkenna Islands and the Gabes vicinity.

Deep Test Being Drilled In Malta near Valletta

BP Exploration Company planned to spud its first deep test on Malta in September. Known as Naxxar 2, the well was located four miles northwest of Valletta. A shallow well was drilled nearby in 1955.

A rig capable of 15,000 feet was moved to Malta from Sicily. The deep test is being drilled pursuant to a new license granted to BP early in 1958 by the Maltese government.

Alpine Geology Studied Through Seismic Surveys

Four seismologists from British Petroleum Company Ltd's Exploration and Production Laboratory at Sunbury went to the Franco-Swiss Alps region in September to partake in a series of large-scale seismic studies.

A series of explosions ranging from 200 pounds to 20 tons of dynamite was to be detonated in a lake in the French Alps. Observers in Switzerland, Italy and France were due to record impulses bearing on the deep-seated geology of the Alpine region.

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Sun Atlantic Get New Venezuelan Wells

Two more oil producing wells have been completed by the Venezuelan Sun Oil Company, Venezuelan Atlantic Refining Company and Texaco Seaboard Inc. group on their Block No. 1 concession in Venezuela's prolific Lake Maracaibo.

The two wells tested at the total rate of 9,385 barrels of oil per day. Both were completed in the Eocene horizon.

SVS No. 16, the larger of the two wells, was completed as a dual producer, and on ¾-inch chokes tested 3,265 barrels per day of 35.2-degree gravity oil and 5,180 barrels daily of 35.7-degree oil, both from the Eocene sands.

SVS No. 15 flowed 940 barrels daily of 35.4-degree gravity oil on a ½-inch choke, with perforations between 8,447 feet and 8,594 feet.

Bolsa Chica Oil Plans Second Test in Turkey

Bolsa Chica Oil Corporation has abandoned Zengilan No. 1 in Turkey at 6,449 feet. It was the first in a series of exploratory wells to be drilled by the company and its associates on a 370,000 acre block in the republic.

No significant oil showings were encountered. Geological information indicated that the well was located off the axis of the subsurface fold at depth. The data will be of value in locating a later test of the Zengilan structure.

Drilling equipment subsequently was being moved approximately 17 miles east of Zengilan No. 1. Location had been made there for Bolsa Chica Oil Corporation's Hazro No. 1. Drilling on this second well, on a separate closure of considerable magnitude, was due to start about the middle of October. It was estimated that a depth of 6,000 feet would be sufficient to test this structure.

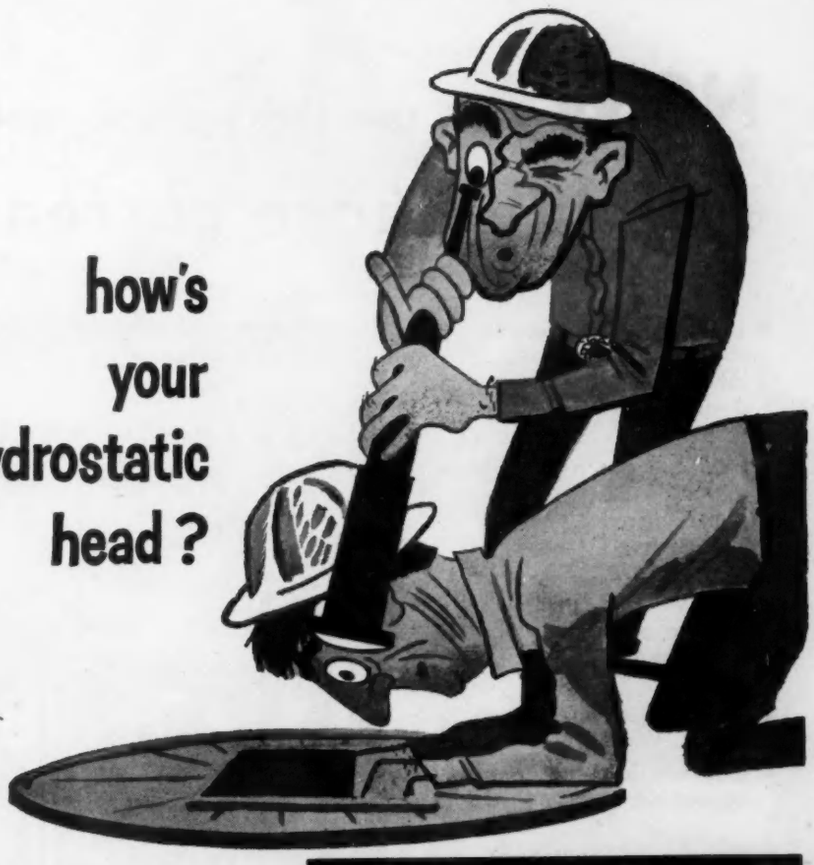
As in the case of Zengilan No. 1, substantial dry-hole contributions have been pledged toward the drilling of Hazro No. 1 by major oil companies holding licenses in the general area.

Phillips Acquires More Concessions in Algeria

Phillips Petroleum Company has been awarded exploration permit interests on two additional concessions in the Sahara Desert of Algeria.

One concession, known as El Atchane, comprises 1,748,260 acres southwest of the prolific Hassi Messaoud oil field. It has been awarded to a group consisting of Phillips and two French companies, COPEFA (Compagnie Francaise des Petroles France-Afrique) and OMNIREX (Omnium des Recherches et Exploitations Petrolieres). Phillips will have 49 percent interest in the venture and will be the operator. Geophysical exploration work will begin in the near future. Phillips and the same partners earlier this year received a concession covering 815,430 acres in the same general area.

The other new award to Phillips is a 25 percent interest in exploration permits on a concession in Algeria comprising 1,433,203 acres in the Sahara Desert adjacent to the country of Tunisia. The area, known as Beressof, is located northeast of the Hassi Messaoud field. COPEFA will be the operator of this property and it is expected that exploration work here will also begin in the near future.



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Aramco Plans Unattended Gas-Oil Separator Units

Arabian American Oil Company has converted one gas-oil separator plant (GOSP) to be constructed in the Shedgum area of Saudi Arabia to automatic operation. They may convert as many as seven such existing GOSP's to automatic control.

Each is designed to handle 100,000 barrels of oil daily or more.

The plans are partly an outgrowth of the success of Aramco's and Tapline's unattended pipe line booster stations installed during the past two years.

Signal Group Opens New Pool in Lake Maracaibo

A new wildcat pool discovery has been made in Lake Maracaibo, Venezuela, by the Signal-Hancock-Pure-Sohio group. The discovery well, Centro 5X, flowed 2,280 barrels per day of 38.1 gravity clean oil from Eocene sands. The well is three miles north of nearest production, found in Centro 3 X.

The new discovery well is five miles north of the group's Centro 6X, which flowed at the rate of 5,880 barrels per day through 203 feet of perforations from the C-5 and C-6 zones. Centro 6X showed 40.7 gravity oil and shut in tubing pressure of 2,500 pounds. Centro 6X is 1¼ miles southwest of Centro 4-X.

These wells have been shut in, pending completion of production facilities.

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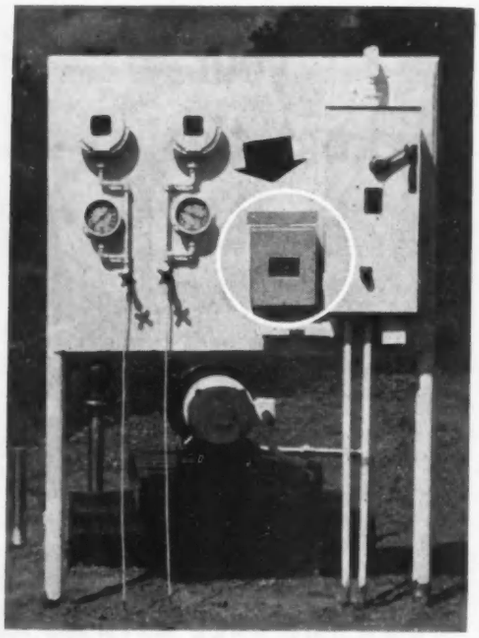

5-hp three-phase motor using single-phase current to operate line pump for gathering system owned by major pipe line company. One of a number of such units in this field, all H-A-S equipped.

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AUSTRALIA: Sun Oil Company of California reportedly will drill a wildcat test at Maitland, 120 miles north of Sydney.

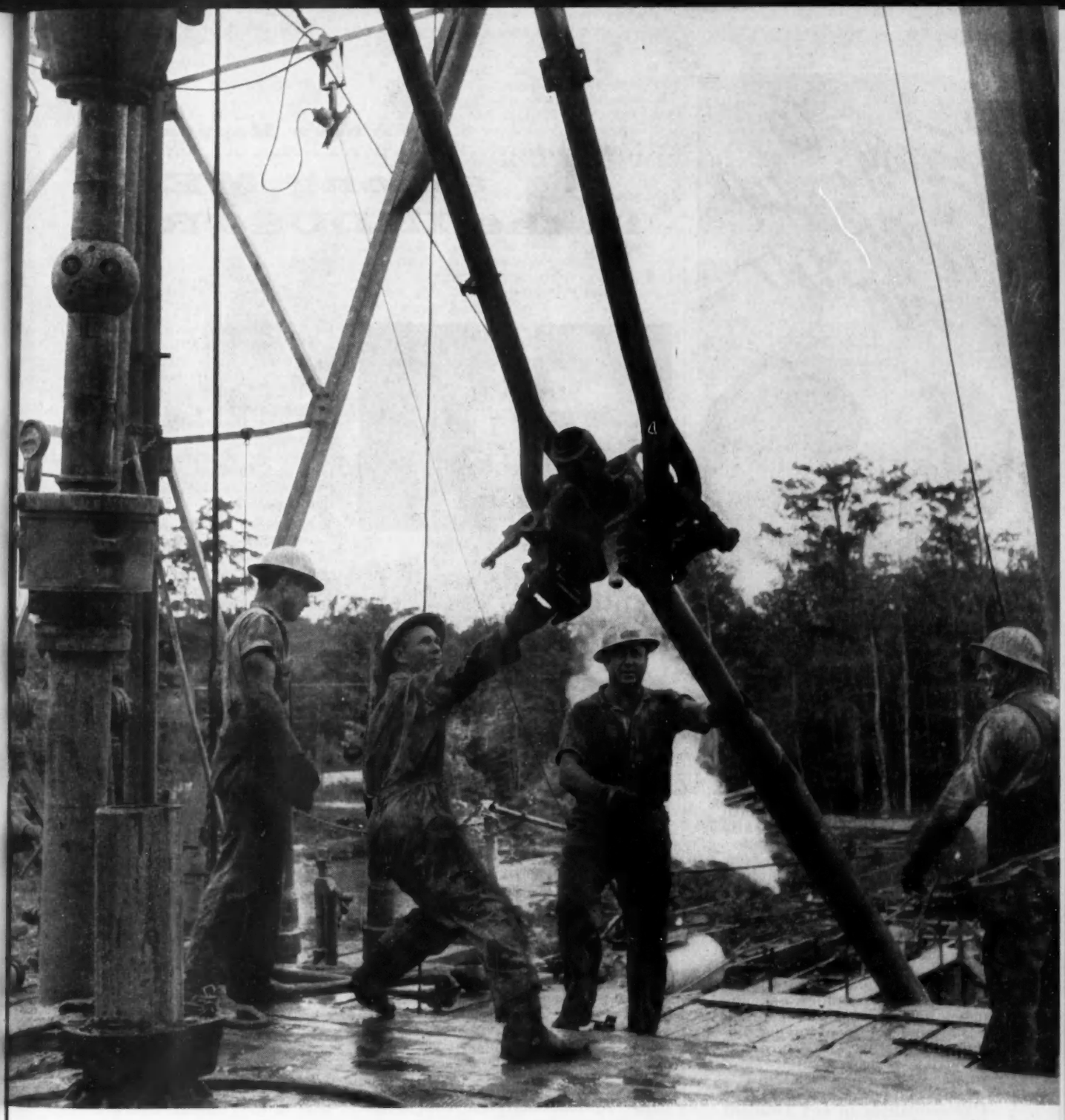
CHINA: An oil discovery at Hochwan, in central Szechwan Province, was reported in August, 1958, at a depth of 3,700 feet.

COLOMBIA: Texas Petroleum Company reportedly signed a contract with the government recently by which the company undertakes to explore for oil in about 100,000 acres in the Suesca area north of Bogota.

ISRAEL: The trans-Israel pipe line system was reported operating at about 23,000 barrels of crude daily in August, 1958. Crude is being pumped from Elath on the Gulf of Aqaba to Haifa.

PAKISTAN: Plans were being made for construction of a new refinery in Karachi, Pakistan, by a consortium of four company groups, Burmah Oil Company, Standard-Vacuum Oil Company, California-Texas Oil Company and Royal Dutch-Shell. The new plant was to have a daily capacity of 30,000 barrels when completed.

SAUDI ARABIA: Arabian American Oil Company is drilling Manifa 2, confirmation test to last December's second offshore discovery in the Persian Gulf. Manifa 2 is located 4½ miles southeast of Manifa 1.



Deep Hole in Assumption Parish. Here's a part of a Falcon Seaboard crew working on a deep-well job in Assumption Parish, Louisiana, just a few miles north of the Gulf. When the picture was taken, they were coming out of the hole, which had reached a depth of more than 13,000 ft. Plans called for setting a string of 7⅝-in. casing, then drilling to a final depth of about three miles.

The rig was equipped with a Bethlehem rotary line, a 1¼-in. rope with tremendous reserve. It had the great strength and toughness that are always needed to handle drill pipe and casing. Bethlehem also furnished the coring line, which was shielded from moisture and gases by a heavy bethanized coating.

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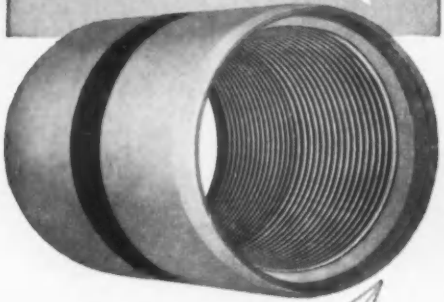

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What's Happening among MEN in the INDUSTRY

M. J. Epley, Jr.

Oscar J. Dorwin

The Texas Company announced the election of a senior vice president and two vice presidents. **Oscar John Dorwin,** formerly vice president and general counsel, was elected senior vice president and continues as general counsel. **Marion J. Epley, Jr.,** assistant to the chairman, was elected a vice president of the company. **Kerryn King,** formerly general manager of the Industrial and Public Relations department, was elected vice president in charge of that department.

Kerryn King

Arnold R. Moore has been named manager of the new Electronic Data Processing department for **H. J. Gruy and Associates,** consulting petroleum and geological engineers in Dallas. In the new department, which utilizes the IBM 650 stored program computer and the most recent advances in data processing techniques, Gruy now offers complete data processing and programming of statistical studies, analyses and predictions to meet the demands for fast, accurate information.

Dee J. Kelly was appointed general counsel for the Moncrief oil interests. Kelly is presently associated with the Fort Worth law firm of Cantey, Hanger, Johnson, Scarborough & Gooch.

Horace Wright McGee has been named district geologist and supervisor-in-charge of **Pan American Petroleum Corporation's** East Texas district, located in Tyler, Texas.

Emmet C. Wilson, manager of the Land department of **La Gloria Oil and Gas Company,** has been elected a vice president of La Gloria.

Pan American Petroleum Corp. is transferring its overseas operations in the western hemisphere to the jurisdiction of its subsidiary, Pan American International Oil Co. **G. J. Smith, D. W. Farnham** and **K. C. Thompson** have moved from Tulsa to the New York offices of Pan American International. All three have been associated with exploration, drilling and production activities of Pan American Petroleum subsidiaries operating in the Caribbean area. Smith's new title is exploration superintendent for the Western Hemisphere; Thompson is chief geophysicist, and Farnham is operating superintendent in Pan Am International's Production department.

J. N. Conley has opened an office in Denver for **Kilroy Company of Texas, Inc.,** as exploration manager for the Rocky Mountains. For the past three and one-half years, he had been located in Denver as chief geologist for the Western division of Seaboard Oil Company.

Tennessee Gas Transmission Company has made some personnel changes in its Production and Exploration departments. **R. N. Walker,** district production superintendent, Bellaire district, will be transferred to the new Durango district with the same duties. **R. M. Stephens,** formerly chief petroleum engineer, will replace Walker, and **H. E. Rowe, Jr.,** Mid-Continent division petroleum engineer, will become chief petroleum engineer. **P. H. Lenhart,** Great Bend district petroleum engineer, will replace Rowe, and **L. W. Rogers,** petroleum engineer, Oklahoma City district, will replace Lenhart. **J. J. Lacey,** petroleum engineer in the Wichita Falls district, will be district petroleum engineer at Durango. **D. P. Dampf** will move from the Hobbs district to the new Shreveport district as district production superintendent. **Dewitt Coffey,** Oklahoma City district production foreman, is to replace him as district superintendent at Hobbs. **H. O. Stallings,** senior petroleum engineer, will become district petroleum engineer at Shreveport. **J. F. Mayfield,** Gulf Coast division petroleum engineer, will transfer to the Houston office as equipment engineer. **W. T. Wells, Jr.,** Wichita Falls district petroleum engineer, will replace Mayfield, and **E. L. Freund,** petroleum engineer in the Houston office, is to assume Wells' former duties. **Donald I. Gahagan,** staff geologist in the Houston office, is due to be district exploration manager, Bellaire district. The new district exploration manager, Wichita Falls district, will be **Donald L. Hellar,** formerly district manager in the Wichita, Kan., district. **N. B. Venus,** district exploration manager at Salt Lake City, will be transferred to the new Jackson, Miss., district with the same duties. **R. B. Ross,** district geologist, will transfer from the Bellaire district to Jackson. **W. H. Medary,** Roswell district geologist, will move up to district exploration manager at Midland. **Robert M. Grace,** who will be district geologist at Midland, will transfer from the Salt Lake City district. **Beryl D.**

Carey, Casper district, will be promoted from geologist, senior, to district geologist. **Claude B. Kirby, Jr.**, district geologist, will move from the Wichita district to the Durango district.

Dr. F. W. Oudt

W. M. Johnson

Shell Oil Company's New Orleans exploration and production area management organization made several changes. **Dr. F. W. Oudt,** area exploration manager, has been promoted to executive assistant to the vice president. He succeeds **W. M. Johnson,** who will continue to assist the vice president with industry affairs and special assignments. **G. A. Burton,** area geologist and for the past year on special assignment in the company's New York office, has been appointed area exploration manager succeeding Oudt.

G. A. Burton

Bailey Selburn Oil & Gas Ltd. has announced the appointment of **C. M. MacInnes** as secretary and **H. W. Bliss** as treasurer of the company.

Max L. Passante has been appointed to fill the newly created post of director of foreign operations for **Lion Oil Company,** division of Monsanto Chemical Company.

Robert I. Bradley, independent consulting engineer of Tulsa, will act as a part-time assistant professor of petroleum production at the Tulsa University beginning this fall.

Bob Franklin has been named drilling department representative for **Warren-Bradshaw Exploration Co.** of Tulsa. He will be headquartered at Midland, Texas.

Dr. Judson L. Anderson, geologist and engineer, has joined the Oil and Gas department of Chemical Corn Exchange Bank.

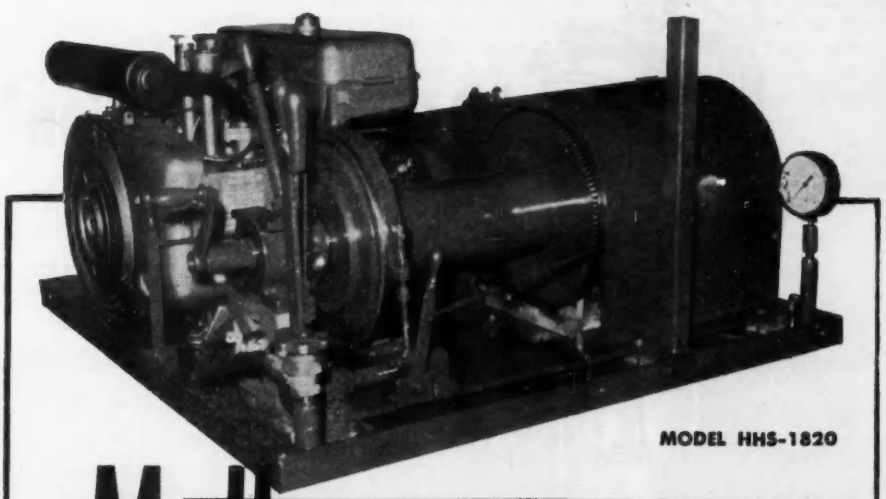
Sun Oil Company has made some appointments and promotions of geological and geophysical personnel carrying on Sun's search for oil in South America. Named to positions in the company's Latin American division, at offices in Caracas, Venezuela, were **P. W. McFarland,** formerly division chief geologist, appointed exploration manager; **L. C. Smith,** appointed division chief geologist. Smith was previously assistant chief geologist; **L. M. Rucker,** promoted from district paleontologist to regional paleontologist; **J. A. Waller,** formerly district geophysicist, promoted to division geophysicist; and **R. C. Weart,** named research geologist. Weart was formerly with Sun's Physical Research Laboratories in Dallas. Personnel changes in the subsidiary Venezuelan Sun Oil Company are **C. E. Lehecka,** former district geologist, named regional geologist at Caracas.

Appointed district geologists were **J. D. Taylor** (Maracaibo district) and **D. W. Simmons** (Eastern Venezuela district). Both men formerly held the position of geologist. In Colombian Sun Oil Company, another Sun subsidiary, **E. C. Robinson** has been promoted from geologist to district geologist at Bogota.

James R. Crow, John F. Bricker and **Fernando Freyre** have formed a partnership called **Pan American Consultants,** specializing in oil and gas throughout Latin America. Bricker has management duties; Crow has geological and Freyre has legal. Their offices are maintained in The Casualty Building, New Orleans, and Ambar Motor Building, Havana, Cuba.

Utah Southern Oil Company has made two appointments to the management staff of **Karl R. Kuhn,** office manager, has been elected to the position of treasurer and assistant secretary, and **Harry E. McDonald** has been named production superintendent.

Tennessee Gas Transmission Company has promoted two of its oil and gas explora-



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tion personnel in the Rocky Mountain area. **Joe M. Wolfe** has been promoted to assistant division exploration manager and transferred to the company's Rocky Mountain division headquarters in Denver. Wolfe was formerly district exploration manager for Tennessee Gas at Casper, Wyo. **Robert L. Sielaff** is division exploration manager at Denver. Succeeding Wolfe at Casper as district exploration manager is **Carl E. Jenkins,** who has been serving as district geologist in the Casper office.

Gulf Oil Corporation elected **George W. Wyckoff,** Pittsburgh business and civic leader, to serve as a Gulf director. Also **Ralph O. Rhoades,** Gulf director and senior vice president, was elected executive vice president, succeeding **David Proctor.** Proctor was elected chairman of the board, a post that has been vacant since 1957.

C. A. Sullins has been named successor to **C. A. McDowell,** who retired recently as general superintendent of drilling and production for **Union Producing Company.** Sullins has been district drilling and production superintendent in Beeville, Texas, for the past 10 years.

Dr. Eldred W. Hough, University of Texas petroleum engineering professor, has received a $4,500 American Petroleum Institute grant-in-aid to continue basic research on "interfacial tension in synthetic condensate systems."

K. W. Brill was elected vice president of **Continental Oil Company.** Formerly assistant to the vice president, he will continue to make his headquarters in New York.

Ralph L. Gray has recently opened an engineering-production consulting office in Artesia, N. M., to serve the petroleum industry in southeast New Mexico.

Willis M. Decker's duties as Oklahoma City district geologist in charge of development for **Cities Service Oil Company** have been expanded to include exploration activities.

L. E. Brock has been appointed assistant to the production superintendent at **Pan American Petroleum Corporation's** North Texas-New Mexico division, which is headquartered in Fort Worth.

Ira H. Cram has been elected chairman of the executive committee of **Continental Oil Company's** board of directors. Cram, who is a director and senior vice president of Continental, succeeds **E. F. Battson,** whose retirement as a director was announced recently.

Charles F. Bedford has been appointed vice president-production and a director of **Pan American International Oil Company,** a subsidiary of Pan American Petroleum Corporation. He was succeeded at Pan American International by **Thomas C. Borland,** who was formerly division production superintendent of the Canadian division in Calgary, Alberta.

Louis J. Brunel, vice president and general manager of **Bishop Oil Company,** was elected a director of the company. He fills a vacancy on the board created by the resignation of **Prentiss Moore of Los Angeles.**

J. Edward Green has been named regional geologist for the southern region of Oklahoma of **Sun Oil Company.** Green, for-

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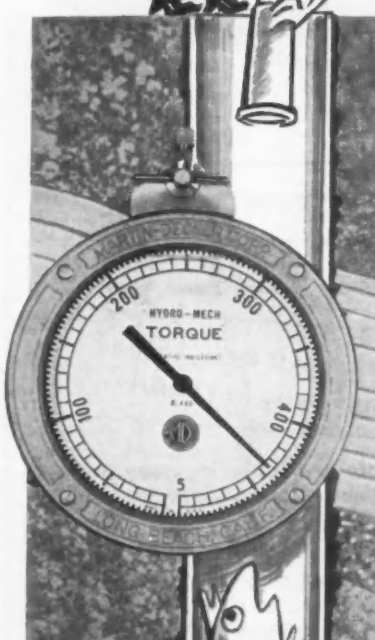

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1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Wm. G. Dudley, 4742 Banning, Houston, Texas; Editorial Director, Warren L. Baker, 5324 Cherokee, Houston, Texas; Managing Editor, Wallace Fitzgerald, 5423 Lymbar, Houston, Texas; Business Manager, Robert M. de Sombre, 4410 Ingersoll, Houston, Texas.

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3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: NONE.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semiweekly, and triweekly newspapers only.)

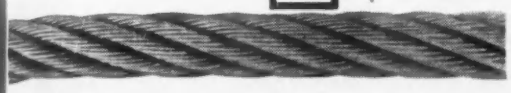
R. M. de SOMBRE
Business Manager

Sworn to and subscribed before me this 19th day of September, 1958.

P. J. AUCOIN

(Seal) Notary Public in and for Harris County, Texas.
(My commission expires June 1, 1959.)

Tips



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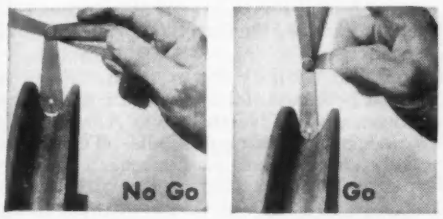
15/8 - 21/4	+ 3/32"	+ 3/16"
23/8 and larger	+ 1/8"	+ 1/4"

How to check groove diameter:



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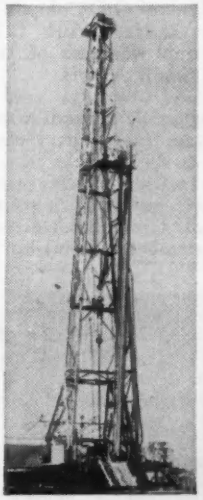

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merly district geologist at Ardmore, Okla., is located in Tulsa, headquarters of the Mid-Continent division. **Richard L. Rison,** geologist already located at Ardmore, will succeed Green as district geologist there.

Signal Oil and Gas Company reported that **Andrew G. Alpha** has been transferred to the general offices in Los Angeles as exploration coordinator. Alpha had been with Signal's Denver office since 1953, when he joined the company as geologist for the Rocky Mountain area and Canada.

I. J. Pierce has joined **Reading & Bates Offshore Drilling Co.** as manager of the firm's newly created Land and Exploration department.

W. B. Cleveland was elected to the board of directors of **Creole Petroleum Corporation.** He replaces **Dr. W. L. Butte,** who has resigned to accept an appointment as professor of law at The University of Texas.

DEATHS

Alonzo Williams (Al) Peake, 68, retired Standard Oil Co. (Indiana) president, died August 28 while in Dundee, Scotland.

Daniel Steen Fletcher, 65, president of the Fletcher Oil Co., died August 28.

Richard A. Bramkamp, 48, chief geologist of the Arabian American Oil Company, died September 1 in a New York City hospital. Dr. Bramkamp was one of the pioneer geologists in Saudi Arabia.

Woodward Darr Clark, 59, retired president of Royal Oil and Gas Corp., died September 3

Lloyd G. Smith, 67, a retired vice president and director of Creole Petroleum Corporation, died September 9 at his home in Media, Penn.

W. C. Windsor, Sr., 67, Texas oil executive, died September 10, at Windsor Place, the family farm near Boonville, Mo.

Charles McKeever, Sr., retired oil man, died September 8.

Laurence M. Marks, 66, a director of Shamrock Oil and Gas Corporation (among other companies) and senior partner of the New York investment banking firm of Laurence M. Marks and Company, died in a New York City hospital August 25.

Harry Leonard, 75, organizer of the Leonard Oil Company, died September 13.

Ferd J. Spang, 66, president of Spang and Company, died in a Cleveland, Ohio, hospital, September 10.

Fred Eugene Houston, Sr., 49, superintendent for the Fred P. Schoenwald Oil Co. of Oklahoma City, died September 23.

Roy W. Henderson, 46, vice president and assistant general manager of Baker Oil Tools, Inc., died June 24 in a Houston hospital. He got his start with the company as a trainee at the Los Angeles office in 1936. Henderson was made company vice president in 1949 after his transfer to the Houston division. He was made assistant general manager in 1951.

Milan G. Arthur, 44, chief valuation engineer for the Union Oil Company of California, died July 29 in Fresno, Calif.

Charles M. Ross, 60, recently retired geophysicist with Amerada Oil Co., died August 3.

Herschel B. Hamilton, 73, pioneer Oklahoma independent oil producer, died August 2.

Louis Lesseig, Tulsa, retired oil production man, died August 3.

Dr. Charles E. Decker, 89, professor emeritus of paleontology at the University of Oklahoma, died August 23.

J. E. (Eddie) Prendergast, 31, administrative assistant to the manager of Sun Oil Company's Southwest Production division at Dallas, died August 12 at his home in Dallas.

Dr. Sam T. Yuster, professor of petroleum engineering at the University of California, Los Angeles branch, died July 3. He was responsible for many of the present-day methods used in secondary recovery operations.

Fred Sehmann, former executive vice president of the North Texas Oil and Gas Association, Wichita Falls, Texas, died July 29.

John Dock, 52, an Arabian-American Oil official, died August 19, on a company plane flying him to the United States.

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what's Happening

among INDUSTRY ASSOCIATIONS

Houston NOMADs Have Football Night

Houston NOMADs were treated to a combined Rice Institute-University of Houston football night at the College Inn recently. The largest number of NOMADs ever to attend a Houston dinner meeting were present. International guests attending were (front row) Carlos Amorim, Petrobras, Brazil; Robert Ford, Schlumberger Surenco, Venezuela; R. Henderson, Henderson Oil Well Drilling Co., Trindad; George S. Ormsby, Pioneer Specialities, Inc., Houston. (Back row) L. Camacho, Bolivian Consulate, Houston; Richard Engebrecht, Asiatic Petroleum Co.; W. W. Gehrig, Reed Roller Bit Co., Berlin; Reeves Morgan, Socony Mobil Co., Turkey; Andre Casassus, C.F.P.A., Algiers, W. Harcher, Southeastern Drilling Co., Turkey; and Ralph Redd, Southeastern Drilling Co., Turkey.

H. C. Pyle to Head AIME As President in February

The American Institute of Mining, Metallurgical, and Petroleum Engineers announced the election of Howard C. Pyle, of Los Angeles, as president to take office for one year beginning at the AIME annual meeting in San Francisco in February, 1959. Dr. Augustus B. Kinzel, of New York, is currently president, continuing in that post until the February convention.

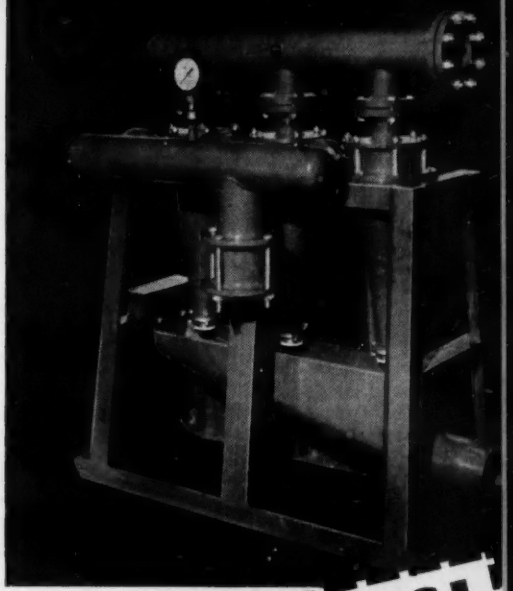
Pyle is president of Monterey Oil Co., and Dr. Kinzel is vice president-research, Union Carbide Corp.

These include Dr. Joseph L. Gillson, chief geologist of E. I. du Pont de Nemours & Co., to become president-elect, pointing to the AIME presidency in 1960 following Pyle's term. Others are vice president, Thomas C. Frick, regional manager, The Atlantic Refining Co.; vice president, Dr. Walter R. Hibard, Jr., manager, Alloy Studies Research, General Electric Co., now president of The Metallurgical Society of AIME; vice president, Elmer A. Jones, division manager, St. Joseph Lead Co., former president of the Society of Mining Engineers of AIME; vice president, John C. Kinnear, Jr., McGill, Nevada, general manager, Nevada Mines division, Kennecott Copper Co., former president of The Metallurgical Society.

Vice presidents have been named for one year. New directors named for three years, will be John S. Bell, area manager, Humble Oil & Refining Co., who is president-elect 1959 of the Society of Petroleum Engineers of AIME; Dr. John C. Chipman, Massachusets Institute of Technology, who will become president of the Metallurgical Society in February; Dr. Arthur B. Cummins, manager. Central Chemical and Physical Research Dept., Johns-Manville Research Center; Dr. Carleton C. Long, research director, St. Joseph Lead Co., who will become vice

New York NOMAD Golfers

Senior Regent Herb E. Maland, R. J. Eiche & Associates, Inc., is presenting the President's Cup to J. E. George (right) of Mid-Continent Supply Co. at the New York Chapter of NOMADs fall golf party held recently. George had the lowest gross scores for both the spring and fall golf parties.



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president of The Metallurgical Society in February, pointing to its presidency in 1960; Jerome W. Woomer, Pittsburgh consultant, who in February also will become president of the Society of Mining Engineers.

API and AAODC Sponsor Oil Well Blowout Safety

A training program for the prevention and control of oil well blowouts is being sponsored by the American Association of Oilwell Drilling Contractors and American Petroleum Institute.

The first objective of a committee headed by Frank Whitby, BB&M Drilling Company, Houston, has been completed. This was the production of two educational films and a manual to be used as training aids.

The second phase of the program now gets underway. This will be the presentation of short seminar-type courses in various areas. These courses will be conducted by the Petroleum Extension Service, The University of Texas.

The seminars will consist of two programs. Program No. 1 is for drilling supervisors (superintendents, engineers, toolpushers.) This is a two-day program. It will be offered wherever 15 or more individuals are interested.

Program No. 2 is for drilling crews. It will consist of four three-hour classes. Each class will be held twice daily on four consecutive days, so members of evening, daylight and graveyard tours may attend. It will be offered wherever 15 or more individuals are interested. Classes will be limited to a maximum of 25, usually 20. The registration fee will be $15 per enrolee.

For additional information address the Petroleum Extension Service, The University of Texas, Box 8024, Austin 12, Texas, or the Dallas offices of either the American Petroleum Institute or the American Association of Oilwell Drilling Contractors.

Guests of LA NOMADs

Guest speaker and international guests at a recent meeting of the Los Angeles chapter of NOMADs are (left to right—standing) Fred N. Willey of Kuwait Oil Company from Kuwait; Carl N. Huff of Tidewater Oil Company from the Middle East; Dick Hoerner, speaker; A. F. Driskill, retired from Iraq Petroleum Company; (seated) Howard Bryan of Dunlap & Graham from Uruguay; Cordell Vincent of I.O.E.P.C. from Iran; and A. J. Hood of Santa Fe Drilling Company from Iran.

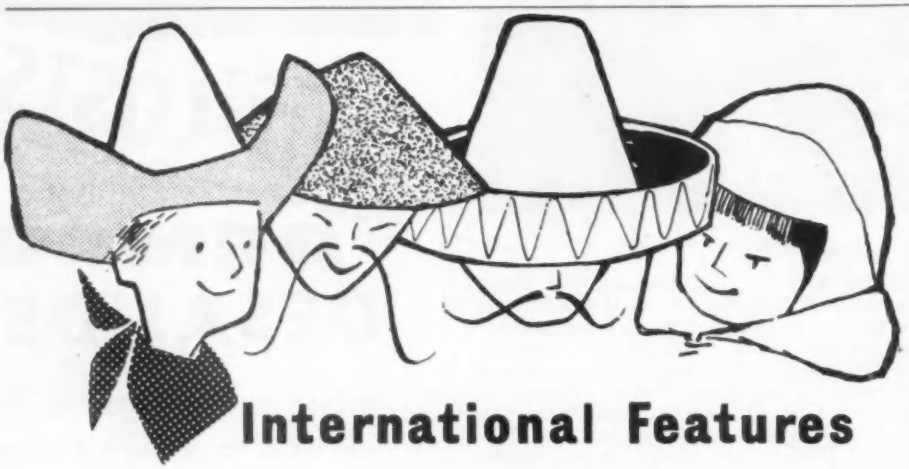
Zeppa Succeeds Teague As AAODC President

Joe Zeppa, president, Delta Drilling Company, Tyler, Texas, was elected president of the American Association of Oilwell Drilling Contractors for 1959. The election took place at the Association's eighteenth annual meeting in Dallas on October 2. He succeeds J. U. Teague, president, Columbia Drilling Company, Houston.

The new national vice president of the organization is George P. Livermore, Livermore Drilling Company, Lubbock, Texas. Ray Wiley, Ray Wiley Drilling Company, Carmi, Ill., was elected vice president for Cable Tools.

The following regional vice presidents were elected: for West Texas and New Mexico: H. Don Johnson, Carl B. King Drilling Company of Texas, Midland; Gulf Coast: Morris McDannald, Mac Drilling Company, Houston; Central Mid-Continent: Frank G. McClintock, Zephyr Drilling Corporation, Tulsa; Rocky Mountains: F. M. Stevenson, Signal Drilling Company, Denver; for California: William D. Tetsch, Terminal Drilling and Production Company, Los Angeles; Illinois-Michigan-Indiana and Kentucky: Don Slape, Don Slape Drilling Company, Olney, Ill.; Cretaceous and Tertiary Basins: A. Earl White, Mustang Drilling Corporation, Tyler; Well Servicing: E. F. Fullen, Mallard Well Service, Lafayette, La.; North and West Central Texas: M. G. Rowe, Rowan Drilling Company, Inc., Fort Worth; Offshore: W. E. Hawkins, Wm Hawkins Drilling Company, Lafayette.

W. L. McClusky, M. J. Delaney Company, Dallas, was elected secretary-treasurer.



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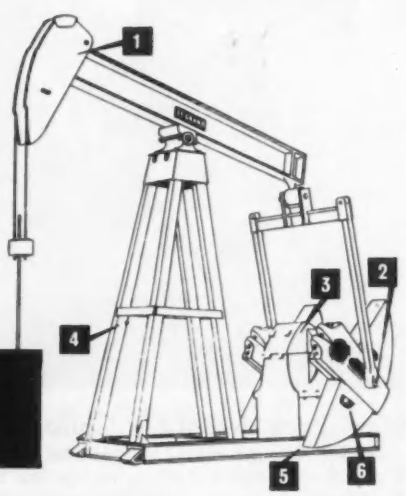

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What's Happening among SERVICE and SUPPLY MEN

James G. Ferguson

Herbert Reimers

Wilson Supply Company, with headquarters in Houston, recently announced the transfer of **James Grady Ferguson** from the Houston office to the sales office in Tulsa, where he will assist **P. S. (Phil) Stover.** Ferguson has been with the company 12 years. He is being replaced in the Tubular Goods department by **Herbert Reimers.**

Ken W. Davis has become chairman of the board of **Mid-Continent Cummins Export Corporation.** Succeeding Davis as president of the organization, with headquarters at Fort Worth, is **T. N. Shults,** vice president of Mid-Continent Supply Co. **D. H. Thornbury,** newly announced president of Mid-Continent Supply Co., has been named vice president of Mid-Continent Cummins Export Corporation. **Jack George**, was also named vice president.

T. N. Shults

Hughes Tool Company has announced some changes in its key sales personnel. **Park L. Myers** has been made manager of U. S. and Canadian sales, and **E. M. Connor** manager of export sales. Both are under **W. H. Siems,** general sales manager. Export sales activities have been divided into Western and Eastern Hemisphere territories, with **O. B. Latrobe,** New York, heading Western Hemisphere sales and **R. G. Roberts,** London, Eastern Hemisphere sales. **Leon Stinson** moves to Houston as director of sales training. **J. R. Lesch** moves to Houston as manager-rock bit sales. **R. W. Lewis** becomes manager—tool joint sales. Throughout the U. S. and Canada new regional and divisional organizations have been added or realigned to furnish improved service. Seven new regional headquarters with respective managers are as follows: Dallas, **T. G. Whiddon;** Houston, **W. W. Hampton;** Denver, **S. J. Lintzenich;** Midland, Texas, **M. A. Foreman;** New Orleans, **F. T. Alexander;** Tulsa, **H. M. Kelly;** and Canadian, **R. D. Hood.**

Lyndon P. Harman has been named sales manager by **Well Completions, Inc.** He will also assist the firm's staff in planning engineered air or gas drilling programs for operators and contractors.

S. E. Marrs, sales representative, at Lafayette, La., was appointed store manager at Monroe, La., and will also be responsible for Baroid stores at Delhi and Winnsboro, La. **J. Lamar Smith, Jr.,** service engineer, has been transferred from Lafayette to Magnolia, Ark., as store manager. He will also manage stores at Lewisville and El Dorado, Ark. **J. B. Wheat,** sales representative, was transferred from Lake Charles, La., to Jackson, Miss. **P. E. Silver,** service engineer, was transferred from Lake Charles and appointed store manager at Brookhaven, Miss. **J. A. Conway,** service engineer at Lake Charles was appointed store manager at Natchez, Miss., and will also be responsible for the Port Gibson Store. **Sam Hailey,** formerly of Sam Hailey Mud and Chemical Company, has been employed as store manager at Canton, Miss.

Jim Sayers was appointed manager of Canadian operations for **H. C. Smith Oil Tool Co.** He will make his headquarters in Edmonton. For the past several years, Sayers was associated with Security Engineering Division, Dresser Industries, Inc., as regional sales manager of their Rocky Mountain and Canadian divisions. From 1952 to 1956 he was Canadian division manager for the firm.

Jim Sayers

J. C. Mabe, vice president in charge of plant operations for **Chicago Pneumatic Tool Company,** has been named to the board of directors of that company.

George E. Matter has been named executive vice president and general manager of **Homco International, C. A.**

William W. Wingate has been named manager of the Mid-Continent region of the **Du Pont Company's** Petroleum Chemicals division, with headquarters in Tulsa. He succeeds **Charles D. Towery,** who has

DON'T WELD on CASING!

WHY? Because field tests made on "average" oil field welding for mounting scratchers and centralizers have shown a great variation in weld quality, and damage from undercutting, hard spots, and electrolytic corrosion. Now there is no longer any need to depend entirely on welding for scratcher and centralizer installations with possible damage to valuable equipment. You can completely eliminate welding on casing, and at the same time get an economical scratcher and centralizer installation that will not interfere with normal casing running practice . . .

B and W AUTOMATIC STOP COLLARS

Just Slide Them On and Drive Slips Flush with Casing.

Also use B and W Thread-Lock Cages and B and W Thread-Lock Cement to eliminate welding on bottom joints to prevent unscrewing as drilling continues.

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For more data on advertised products, use Readers' Service Cards, last page.

been manager of both the Mid-Continent and Gulf Coast regions and now will devote full time to management of the Gulf Coast regional office in Houston.

Larkin Packer Company has recently added **Kenneth H. Eggers,** vice president of the St. Louis Union Trust Company, to its board of directors. He fills the position left vacant by the death of **T. S. McPheeters.**

Tex-Tube, Inc., has added **Thomas P. Toudouze** to its sales staff in the Houston area.

Robert G. Allen has been elected to the board of directors and the executive committee of **Bucyrus-Erie Co.** Allen is executive vice president of Bucyrus-Erie in charge of all manufacturing and sales. He joined the company in 1957 as a vice president.

Don Walters was appointed to the position of Odessa district manager for **The Western Company.** Walters was formerly assistant Midland division manager. Walters will be in charge of both sales and operations functions in the Odessa district. **Lloyd Helm** will remain as Odessa district operations supervisor, and **A. P. Brown** as district sales supervisor.

Ray Webb has assumed a new position as vice president and general manager of the **Inferno Manufacturing Corporation.** Webb, formerly advertising manager with the manufacturing firm for five years, will continue in that capacity and also assume additional engineering duties.

J. T. Calnon is the new president of **Cummins Sales & Service, Inc.** He was formerly vice president—sales for the Fort Worth firm. **Ken W. Davis,** former president, has been elected chairman of the board. Named vice president and general manager was **L. J. Troutz,** formerly general service manager. Calnon began his service with Cummins Sales in 1945, advancing to vice president in charge of sales in 1952.

J. T. Calnon

Wilbur E. Combs has been appointed manager of development for the Mechanical Goods divisions of **United States Rubber Co.**

Bolling A. Abercrombie was appointed assistant to the vice president-engineering of **Garrett Oil Tools, Inc.,** a division of **U. S. Industries, Inc.** Abercrombie, who has been serving as a sales engineer in the company's Houston district, has moved to Garrett's home office at Longview, Texas.

H. F. Nostrand

H. F. Nostrand has been appointed advertising manager of **W. C. Norris, Manufacturer,** division of **Dover Corporation of Tulsa.** Nostrand, who has been with Norris since 1946, will serve under **G. W. Davidson, Jr.,** vice president—sales of the Advertising department.

Harold E. McGowen, Jr., president, **Camco, Incorporated,** was elected to membership in the Young Presidents' Organization. He will be affiliated with the YPO Southeast Texas Chapter.

Mid-Continent Supply Co. has announced the appointment of **J. H. Kenyon** as sales manager of Mid-Continent. **L. B. Levell,** formerly of Denver, has been named assistant sales manager at the Fort Worth office.

Jones & Laughlin Supply Division announced two changes in its field sales organization. **D. C. Jones,** store manager at Muenster, Texas, was transferred in the same capacity to Graham, Texas. **L. E. Owen,** storeman advanced at Muenster, was promoted to store manager at Muenster.

J. Fred Buckner has been appointed export sales representative in Venezuela by **Byron Jackson Tools, Inc.,** a subsidiary of Borg-Warner Corporation. Buckner will be located at the Maracaibo office of Oilfield Sales and Service, S. S., Venezuelan dis-

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. . . for the life of your well

That's the important thing about the new Jensen Rotary Balanced Jack. It's a rugged unit—with large, heavy main shafts and bearings, a taller, more rigid samson post. Then, too, the Jensen RB Jack offers complete floor clearance, simplified installation. All in all, it's a modern pumping jack—low in original cost, economical to install and operate and built to provide years of long, hard service.

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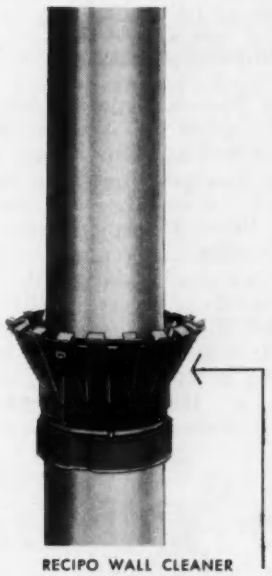
HALLIBURTON RECIPO WALL CLEANERS

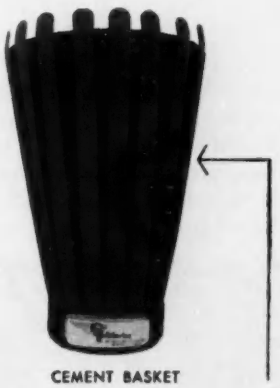
Newest concept of reciprocating type cleaner to remove undesirable filter and mud cake from bore hole giving better bonding of cement to formation and casing. Wide fluid passage areas reduce circulating pressure and bridging action of filter cake cuttings with or without lost circulation materials ... thoroughly cleans wall of hole due to increased velocity. Minimizes bore hole or filter cake damage. Breaks up channeling action through drilling fluid. Greater area cleaned with wide and tough rubber fingers, plus easy and fast latching to casing with hinged design.



RECIPO WALL CLEANER

HALLIBURTON CEMENT BASKET

Basket acts as support after cement is pumped and "bridges" heavy cement columns until initial set. Protects weak formations and retains cement by reducing slurry loss and breakdowns of porous formations. Successful performance when run outside casing or liner above defective formations.



CEMENT BASKET

HALLIBURTON VISE-LOK LIMIT CLAMP

Superior lock-on power handles loads up to 20,000 lbs. This non-weld limiting device sets itself tighter to casing as more load is exerted against it. Greater protection from vertical movement is achieved by special file hard gripping disc slips inside hinged steel ring which are forced against casing by taper pins from behind. Hinged for easy installation, the Vise-Lok eliminates welding of lugs or limiting devices.

VISE-LOK LIMIT CLAMP

LATEX CEMENT

A low fluid loss cement for squeeze cementing or "tailing-in" on primary cementing. Perforating properties exceptional, with minimum shattering as compared to portland cement. Higher resistance to mud contamination, acid and corrosive fluids with added resiliency and bonding qualities to cement.

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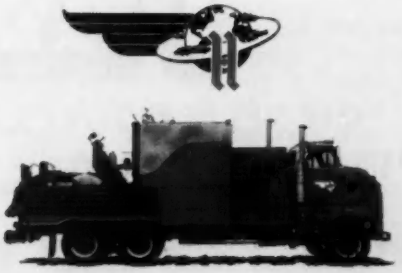


"WORLD-WIDE LEADER IN OIL WELL CEMENTING—RESEARCH AND APPLICATION"

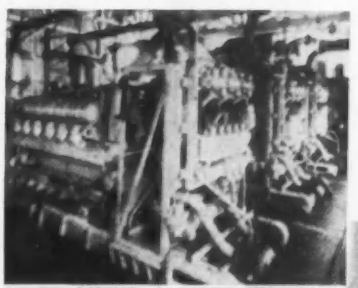
tributor for BJ oil tools. His former Mexico City post will be filled by his former assistant, **Enrique Inclan.**

Baroid Division National Lead Company has announced the appointment of **R. E. Souther** as manager of foreign operations for the company. Replacing him as manager of the Well Logging department is **B. O. Pixler,** formerly assistant manager. **S. E. Geffen** has been appointed area superintendent of Baroid's Well Logging department in Denver, Colo., replacing **Wendell H. Russell,** who has returned to the Houston general offices as assistant manager of the Well Logging department. In Baroid's Drilling Mud department, **H. I. Bussa,** formerly assistant manager of the Lower Texas Gulf Coast area office, has been appointed administrative assistant to the manager of the Drilling Mud department in the general offices. Replacing him in the area office as assistant area manager is **Kemp S. Lewis. B. F. Stiba,** formerly sales representative in the East Louisiana area, has been appointed sales manager in the Lower Texas Gulf Coast area with headquarters in the downtown Houston office.

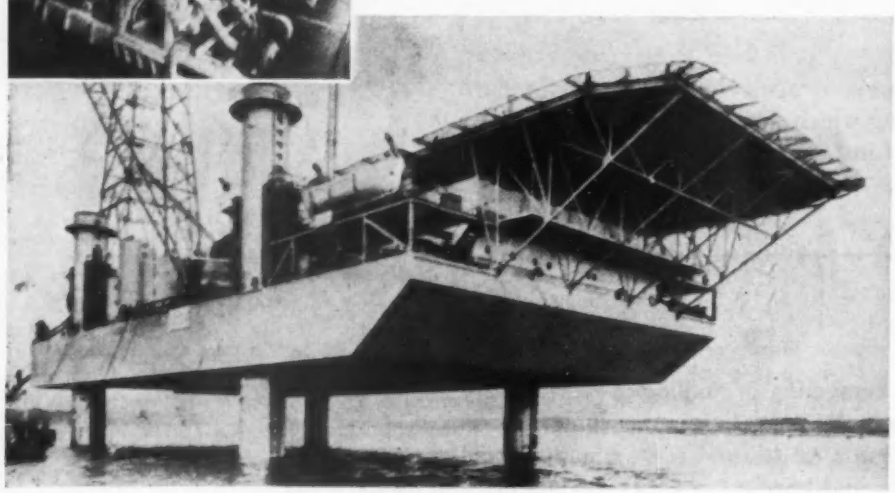
Wilbur Hering Armacost, vice president-consultant and chairman of the technical committee at **Combustion Engineering, Inc.,** New York, was given the American Society of Mechanical Engineers Medal, for distinguished service in engineering and science.

for Offshore Drilling in the Persian Gulf

The A.D.M.A. "Enterprise," built by Gutehoffnungshutte Sterkrade A.G. for Abu Dhabi Marine Areas, Ltd., has a National 130 drawworks powered by four Paxman 12RPH 400 s.h.p. Drilpak units (see inset). The drilling equipment was manufactured by Oil Well Engineering Co., Ltd., and is capable of drilling a hole 15,000 feet deep. The 440-volt main electricity supply is obtained from three 220 kw alternators, each driven by a Paxman 12RPH engine.



THE ILLUSTRATION BELOW SHOWS THE "ENTERPRISE" DURING THE TESTING OF THE RETRACTABLE LEGS. (B. P. photograph.)



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DIESEL ENGINES for OILFIELD DUTY

7" BORE RANGE 128 to 800 S.H.P.
9¾" BORE RANGE 400 to 1,750 S.H.P.

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Petroleum Industry Consultants C.A. operating in Maracaibo and Caracas carry full stocks of spares for Paxman engines. In North Borneo a similar service is provided by Guthrie & Co., Ltd., of Seria

J.43.

Howard Anderson has been named eastern sales engineer for **BS&B International, S. A.,** wholly-owned subsidiary of Black, Sivalls & Bryson, Inc. He has been a sales engineer in BS&B's domestic Oil Field Equipment division for the past three and one-half years.

Calvin O. Bell, Jr., was appointed sales and service representative for the **Mid-States Chemical Company, Inc.,** in the Gulf Coast area with headquarters in Houston.

International Harvester Company, Construction Equipment division, has announced the appointment of **W. O. Bechman** as assistant to the general manager, and **Merrill R. Bennett** as manager of engineering of the division. In his new position Bechman will study the needs of the industry and make recommendations for improvements and new design to division management. Bennett, who succeeds Bechman, formerly was assistant manager of engineering.

John Davis has been named vice president of **Mid-Continent Supply Co. of Venezuela, C. A.** He was formerly Caracas manager and New York export manager for Mid-Continent Supply Co. Davis will help direct the oil field supply company's operations in the rapidly expanding oil centers of Venezuela.

Norvell-Wilder Supply Co. has announced the appointment of **W. C. (Lyle) Wadsworth** as assistant to **John T. Knight, Jr.,** manager of the company's sales office in Tulsa.

George E. Failing Company has announced the appointment of **Harold T. Holden** as manager of export operations.

Baroid Division National Lead Company recently announced several appointments and transfers within its Drilling Mud department. **Kemp S. Lewis,** assistant manager of the Lower Texas Gulf Coast area, has been transferred to Corpus Christi, Texas. **R. E. Killion,** formerly sales representative in Houston, has been appointed district superintendent at McAllen, Texas.

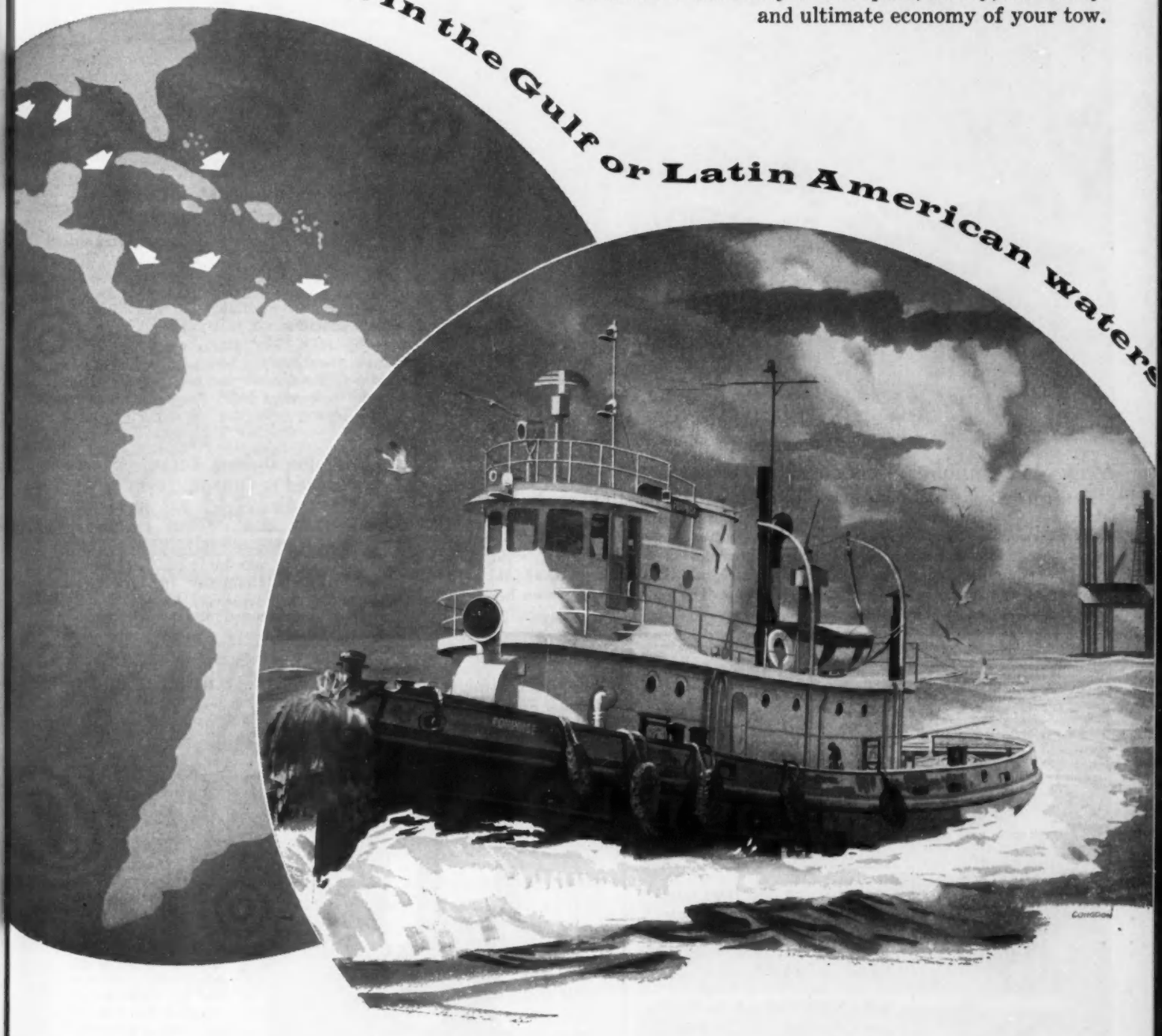
ALCO Products, Inc., has named **John P. Gregor** a sales engineer in Houston for its line of diesel-electric drilling rig power packages.

B. A. Wendt, former assistant sales manager, has been appointed Texas Gulf Coast division manager of **Reed Roller Bit Company,** succeeding **R. V. Ellis** who will transfer to the Southeastern division, Louisiana, as division manager. **A. A. Ezzell,** former Corpus Christi district manager in the Texas Gulf Coast division, has been promoted to division manager of the North Texas division, Wichita Falls, Texas. Reed's Kansas and Oklahoma Sales divisions, including the Panhandle of Texas, will be combined into one division with headquarters in Oklahoma City. **W. H. Armstrong,** presently Kansas division manager, will move to Oklahoma City as division manager.

B. F. Hanly, division manager of Rocky Mountain division, is vacating that post for health reasons. He will assume the position of area representative in Denver. **R. C. Gann,** former division manager of Oklahoma Sales division, is transferring to Casper, Wyo., as division manager of Rocky Mountain division.

When it comes to offshore towing, G & H's 35 years of diversified harbor, coastal and deep sea experience . . . a modern diesel fleet of 700 to 1700 hp tugboats for every towing requirement . . . and fully licensed crews who thoroughly know and understand the sea . . . contribute materially to the speed, safety, efficiency and ultimate economy of your tow.

Anywhere in the Gulf or Latin American waters



. . . If it floats, we can tow it!

Day or Night Phone
Galveston SO 3-6468 or
SO 3-4673
Houston WA 8-5406 or
MI 5-3614
Corpus Christi TU 4-8791
New Orleans JA 5-8697

Pioneers in Gulf Coast tidelands towing, G & H has capably handled every conceivable towing assignment. No job has proved too large. None could be too small. If it floats, G & H can tow it . . . well . . . anywhere in the Gulf or Latin American waters. Call the G & H office nearest you today, and let towing experts help you solve your offshore towing problems. No obligation, of course.

G and H

TOWING COMPANY INC.

FLEET OF MODERN 700 TO 1700 HP TUGBOATS FOR EVERY TOWING REQUIREMENT

CORPUS CHRISTI • GALVESTON, 509 Texas Bldg. • HOUSTON • NEW ORLEANS

Magcobar Supplies Venezuela With Mud

Barite weight material for drilling muds are now produced for western Venezuela by Magcobar de Venezuela, C.A.'s, new plant at Punta Camacho on the Bolivar Coast of Lake Maracaibo. The crude ore arrives by ship and is discharged on a 2,378-foot conveyor belt at the unloading dock (1). It is then moved through the plant to the stockpile (2). After processing, the finished product is often taken to the barge dock (3) for delivery to drilling locations in Lake Maracaibo. The plant office, which houses a two-way radio system, is at left (4).

Houston Electro-Technical Labs Acquires Alberta Office Assets

Acquisition of the assets of Electro-Technical Labs, Alberta, Ltd., has been announced by P. C. Sundt, general manager of Electro-Technical Labs, which is headquartered in Houston. The Canadian company had operated as a separate entity until the recent acquisition.

The E-T L Canadian organization is headed by T. G. Gilbert, manager. He and his staff are headquartered at 322 10th St., NW, Calgary, Alberta, Canada. Gilbert formerly was a sales engineer with Electro-Technical Labs in Houston.

Bethlehem Supply Moves District From Houston to Beaumont

Bethlehem Supply Company announced the removal of the Texas Gulf district headquarters from Houston to Beaumont, Texas. This district now comprises the store areas of Lake Charles, Beaumont and Houston.

O. H. Crowe, Texas Gulf district manager, removed his headquarters from Houston to Beaumont, and the district office is now located at 3675 Port Arthur Road in Beaumont.

Levingston Drilling Barge Christened in Orange, Texas

A new submersible drilling barge, the "Leonard Glade" was christened at Orange, Texas, recently.

This vessel was built by the Levingston Shipbuilding Company in Orange, and Mrs. Leonard Glade of New Orleans, the sponsor, christened the vessel named in

Oil Men Call us "Bankers"

but . . . .

BANKERS CALL US "OIL MEN"

COMPLETE ENGINEERING AND OIL DEPARTMENT

W. L. KENDALL, Senior Vice Pres. — W. L. MORRIS, Engineer

M. R. BILLINGTON, Ass't Vice Pres. — A. D. McCALL, Engineer

IN OIL MATTERS — *IT PAYS TO*

Think 1st *of Tulsa*

FIRST NATIONAL BANK & TRUST CO.

SINCE 1895

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

"I've ALWAYS preferred KING GA SWIVELS"

King Swivels 32GA and 53GA have been popular for many years. They have proved to be rugged, dependable and durable, and are in use around the world because they are "preferred". The fact that King Oil Tools is the largest manufacturer of lightweight swivels is supporting evidence of King engineering, service efficiency and complete all-around dependability.

INDUSTRY RECOGNIZES KING GA SWIVELS BY THESE FAMOUS FEATURES:

- ALLOY STEELS assure strength with minimum weight.
- PACKING is V-type, often called chevron type.
- WASHPIPES are seamless alloy tubes, case-hardened and ground.
- GREASE LUBRICATION for the packing.
- MULTIPLE BALL BEARING UNITS provide ample capacity.
- OIL BATH LUBRICATION for the bearings.
- Choice of BAIL OR ELEVATOR SHANK.

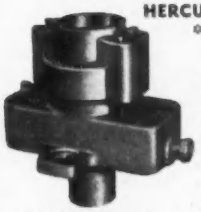
FOR FULL INFORMATION ON ALL KING SWIVELS — SEE YOUR NEAREST DISTRIBUTOR — OR WRITE:

KING OIL TOOLS

P. O. BOX 15146 • HOUSTON 20, TEXAS • ORchard 3-3421

Dependable
HERCULES STUFFING BOXES end Your pumping worries*

HERCULES Duplex Polished Rod Stuffing Boxes are constructed from high grade malleable iron (55,000 PSI Tensile Strength) and are rated 3,000 pound test. Flexibility and the cone-shaped Packing Rings are the combination of factors which make the HERCULES Stuffing Box without equal for any pumping situation.

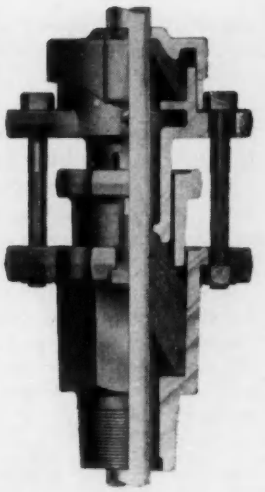


HERCULES OIL RESERVOIR UPPER GLAND

**Any HERCULES Stuffing Boxes may be equipped with Oil Reservoir Upper Glands on "problem" wells which pump-off and burn packing. The polished rod moves through the oil in the reservoir which lubricates and cools it.*

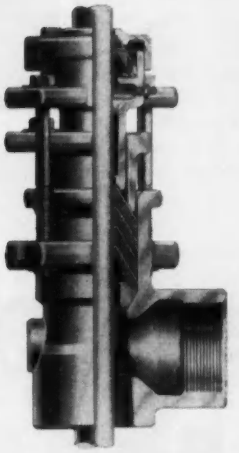
"REGULAR TYPE" DUPLEX POLISHED ROD STUFFING BOX

The old reliable; tried and proved on thousands of wells from coast to coast and in many foreign fields.



"TEE TYPE" DUPLEX POLISHED ROD STUFFING BOX

HERCULES "TEE TYPE" Stuffing Box is very compact, only 15" high. It is full opening which allows rods to be run or pulled without removing Stuffing Box body. It is furnished in 2", 2½" and 3" sizes with any API Tubing or Line Pipe Thread.



"TYPE DP" DUPLEX POLISHED ROD STUFFING BOX

A double packed Stuffing Box for use on high pressure wells and those that flow intermittently. Especially desirable for wells located near buildings, fire hazards or growing crops. Two compression bolts, in bottom sections, are tightened on lower packing set while replacing packing in upper section. Possess same flexibility as the regular and Tee base type.

HERCULES TOOL Company

"MANUFACTURERS OF OIL FIELD EQUIPMENT SINCE 1924"

GENERAL OFFICES AND PLANT — TULSA, OKLAHOMA

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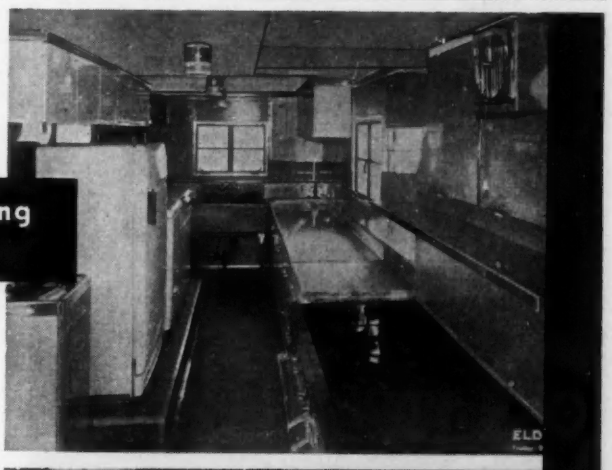
Elder FIELD TRAILERS

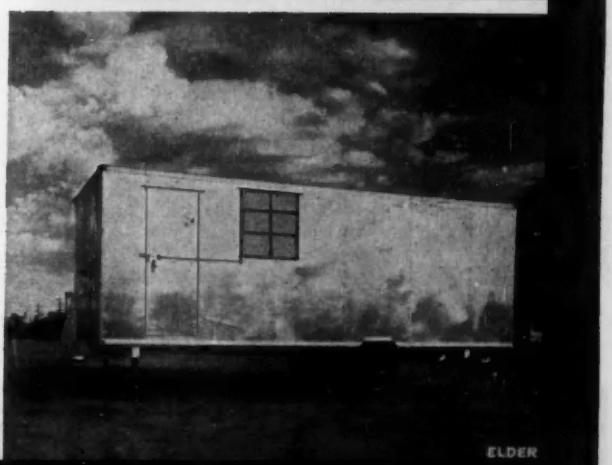
Designed *Specifically* for Field Crews Operating in Remote Locations



Elder trailers are *not* house trailers... they are rugged field trailers, designed and built to give long, trouble-free service under the toughest, off-the-road conditions—especially in foreign countries. Equipped with large sand tires, air conditioning, rugged steel frame, light-weight aluminum body.

IMPORTANT! Elder's special lease plan saves you time and money. You need no capitol investment in trailers, and your *leased trailers are chargeable to expense!* You have no maintenance costs, no time-consuming paper work, to worry about.

TURNKEY OPERATION! We'll operate your camp for you... furnish personnel, food, fuel, laundry and pick-up truck.



QUALITY BUILT TRAILERS FOR EVERY FIELD OPERATION

Kitchen, Diner, Sleeper, Shower, Office, Power Plant, Water Tank trailers

ELDER OIL FIELD FLOAT—SPECIAL RUNNING GEAR, LARGE SAND TIRES, HEAVY DUTY PLATFORM.

ELDER TRAILER AND BODY, INC.

P. O. BOX 9042 4830 RACE ST. DENVER 16, COLO. AMherst 6-1781

honor of her husband, secretary-treasurer of Producers Drilling Company of New Orleans.

Southern Engine and Pump Is Agent for Roi Line Engines

Southern Engine and Pump Company has been appointed distributor for Roi line engines, manufactured by Waukesha Motor Co.

Waukesha Motor Co. recently purchased Le Roi engines and renamed it the Roi line. Southern Engine and Pump Co. for 20 years, distributor for Le Roi engines, will continue the same service for the renamed Roi line.

Diamond award pins were presented to the 10-year men of Varel Mfg. Co., at the awards dinner recently. Shown left to right are Dan W. Varel; Nick Varel, vice president; R. J. Blanton, vice president; W. F. Stewart, J. D. Whaley, M. O. Baxter and Luke Stevens, secretary-treasurer. F. A. Nevil of Odessa, another 10-year man, was not present.

BRITISH HE MADE

300 P.A. TRACTOR DRILLMASTER

MULTI-PURPOSE · HIGHLY MOBILE

The Hands-England Drillmaster 300 P.A. Rotary Drill is now available mounted on a Fordson Major Tractor and is illustrated on left.

This design provides great manoeuvrability and is intended primarily to enable the well known H-E Drillmaster 300 P.A. Rotary Drill to be used for Quarry and Open Cast blast or shot holes.

Although the H-E Drillmaster 300 P.A. mounted on a diesel engined tractor, is ideal for Quarry and Open Cast operations, it is equally applicable to some difficult "off the road" locations, such as may be encountered during seismic exploration particularly in highly cultivated areas.

An air compressor giving 99 C F M can be mounted directly onto the drill subframe and driven from the tractor engine. This compressor gives an up-hole annular velocity of 3,000 ft./min. when using flush jointed drill pipe and holes of the following sizes:

1⅝" o/d.	Drill Pipe	2⅞" dia. hole
1.29/32"	" "	3⅛" " "
2⅜"	" "	3⅜" " "
2⅞"	" "	3¾" " "

Larger holes or holes drilled with mud circulation can of course be drilled, but the equipment for these operations must be mounted on a separate trailer or tractor.

The H-E Tractor Drillmaster will be found to cover the majority of drilling requirements of the Quarry and Open Cast operator, the Geologist, the Mineralogist, and the Geophysicist.

Write for illustrated folders giving full details and specifications of this equipment.

HANDS - ENGLAND OILFIELD EQUIPMENT LTD
MANUFACTURERS OF GEOPHYSICAL SUPPLIES
LETCHWORTH HERTS ENGLAND TEL: 600 CABLES: OIL LETCHWORTH ENGLAND
Exclusive licensees in Western Germany: August Goettker Flachbotrungen, 20a Wathlingen Kreis Celle, West. Germany

Varel Mfg. Co. Honors 60 For 5 or More Years Service

Sixty employes, with more than five years service with Varel Manufacturing Co., were honored August 22 when the company celebrated its tenth anniversary.

Dan W. Varel, president, was host to more than 100 guests, including honorees and their families at Casa Linda Lodge. Service pins were presented to 60 Varel veterans with five or more years service.

Continental-Emsco Co. Announces So. Louisiana Division Formation

Continental-Emsco Company, a division of The Youngstown Sheet and Tube Company, in the Gulf Coast area has decided to divide one existing division into two separate ones. These will now be known as the South Texas division with headquarters at Houston and South Louisiana division with headquarters at New Orleans.

E. A. Dunn, formerly district manager, has been promoted to the position of division manager of the new South Louisiana division. There will be two districts under his supervision: Lafayette district, which includes stores at Lake Charles, Eunice, New Iberia, Morgan City (parts depot and store), and the Lafayette, La., office. The New Orleans district includes stores at Houma, Harvey, Venice and the New Orleans, La., office.

The South Texas division remains under the supervision of R. A. Gentry, division manager. Included in this division are two districts. The Corpus Christi district includes stores at Corpus Christi, Alice, Falfurrias, Refugio, McAllen, Freer and the San Antonio, Texas, sales office.

R. L. Cavnar has been promoted from store manager at Shreveport, La., to district manager of the Houston district. This district includes stores at Houston, El Campo, Luling and Victoria, Texas.

The South Louisiana and South Texas divisions are both under the direct supervision of R. Hortenstine, Jr., vice president.

Cherokee Laboratories, Inc. Acquires McNamar Boiler & Tank

Cherokee Laboratories, Inc., of Tulsa have acquired McNamar Boiler & Tank Co., which will merge with two other steel products companies.

The new firm will be temporarily named Southwest Steel Co., and all manufacturing will be at the McNamar plant loca-

tion. Eventually the company will be named Cherokee Steel, Inc.

The other steel firms which have merged are Southwest Steel Co. and Santa Fe Steel Co., both of Tulsa.

David A. Garrick, president of Cherokee, will be president of the new combine, and James Jackson, president of McNamar, will be vice president. The company will be a subsidiary of Cherokee Laboratories, which owns several other companies.

C. Riker

J. Hamilton

J. Schuelke

W. E. Hill

Johnston Testers, Inc., Forms Marketing Division in Houston

Formation of the Marketing division of Johnston Testers, Incorporated to handle sales and service of the new Sonic Pump being manufactured and distributed by the company, has been announced. The Marketing division of Johnston Testers has set up offices at 930 Bank of the Southwest Building, Houston.

Charles F. Riker heads the new division as general manager. He was formerly a sales engineer for Johnston.

Sales manager for the division is Jack Schuelke, until recently technical editor for WORLD OIL magazine.

District sales engineer with headquarters in Houston is W. E. (Bill) Hill. Sonic pump installation engineer for the organization will be Jim Hamilton.

Milwhite Co. Adds to Line Of Adsorbents for Industry

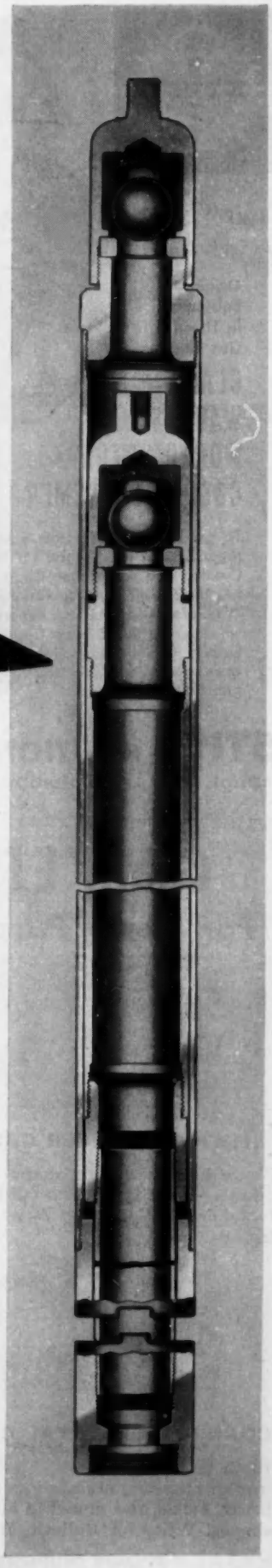
The Milwhite Co., Inc., announces that on or about Jan. 1, 1959, it will complement its line of industrial adsorbents with the introduction of new high efficiency acid activated clay adsorbents for petroleum and edible oil refiners and other process industries.

The Milwhite Co. has contracted with the Morton Chemical Co. for the latter to manufacture these adsorbents by a Milwhite process from extensive reserves of activable Montmorillonite clays.

The clay activation unit now being erected by M. W. Kellogg Co., for Morton Chemical adjacent to their acid plant at Weeks Island, La., was engineered for Milwhite by Kidde Processing Co., of Pasadena, Calif.

*Designed for Your Waterflood**

*WITH THIS PACIFIC INSERT ROD PLUNGER PUMP YOU GET VOLUME *plus*



1 A precision insert rod pump of 4½" O.D. x 3¾" I. D. built to Pacific standards.

2 A specifically designed pump for pumping large volumes of fluid efficiently **at any speed**—fast or slow—with a conventional pumping unit installation.

3 A pump that will seat in a regular production casing packer and may be operated in 5" casing (or larger) thereby eliminating tubing.

4 A pump ideally suited for pumping water supply wells in the range of 2000 to 3000 barrels of fluid per day for water flooding operations.

5 A pump equipped with Pacific Pacilite chrome plungers and the latest design rubber lined cages for long trouble-free operation.

Ask your Pacific field salesman for more details or write:

PACIFIC PUMPS, INC.
A DIVISION OF DRESSER INDUSTRIES, INC.
HUNTINGTON PARK, CALIFORNIA
Mid-Continent Division:
1358 So. Sheridan Ave., Tulsa 12, Oklahoma
Pacific Pumps of Canada, Ltd.,
Edmonton, Alberta

PACIFIC®
DW-18

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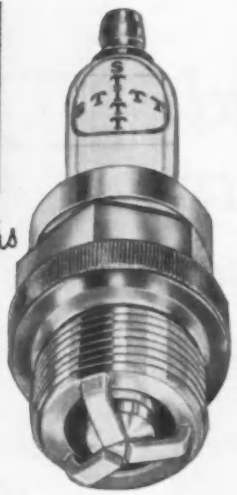

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Original Equipment In These Gas Engines

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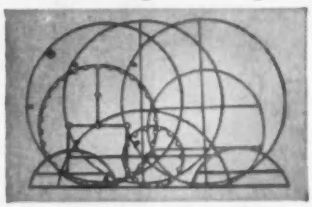
To get better service from your engines—regardless of make—send for FREE Pocket Catalog and Application Chart that specifies the RIGHT plug for ALL your engines. We'll also send you Field Reports which prove STITT New Triple Ignitors give better performance because they hold their gap setting longer.

583

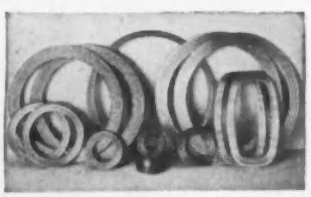
STITT IGNITION CO.
Dept. WO Columbus, Ohio

GASKETS
For Every Purpose



HEAT EXCHANGER GASKETS

Made in any size or shape needed in double jacket type. Also cut from solid metal or sheet packing. Write for Bulletin 564.



CORRUGATED METAL GASKETS

Plain or jacketed type. Made of ingot iron, aluminum, stainless steel, copper, brass, nickel and monel in all sizes and shapes. Write for Bulletin 565.

PROMPT DELIVERIES

CHICAGO-WILCOX MFG. CO.
7705 So. Avalon Ave., Chicago 19, Ill.

SQUEAKS from the BULLWHEEL

"Are we interested in investing in a wildcat well in western Africa?"

Spirit of the Thing

An antique collector passing through a small village stopped to watch an old man chopping wood with an ancient ax. "That's a mighty old ax you have there," he remarked.

"Yup," said the villager, "it once belonged to Sir Walter Raleigh."

"Not really!" gasped the collector. "It has certainly stood up well."

"Of course," admitted the old man, "it's had three new handles and two new heads."

Good Gnus, I Hope

Papa Gnu came home and Mama Gnu looked at him shyly and said, "I've got gnus for you."

Male Suffrage

Until a husband can get alimony by crossing his legs and winking at the judge, there's no such thing as equal rights.

These Dogs

In school one day, a little boy was telling his teacher about his dog.

Teacher: "What kind is it?"

Boy: "Oh, he's a mixed-up kind—sort of a cocker scandal.

Predestination

Three-fourths of the earth's surface is water, and one-fourth is land. It's clear the good Lord intended man should spend three times as much time fishing as he does plowing.

Explanation

A wealthy Texas oilman cashed a huge personal check which came back from the bank with "INSUFFICIENT FUNDS" stamped across its face. Beneath the stamped words was the handwritten notation: "Not you . . . us."

Over
70
Locations in the United States and Canada

McCullough® REPORTS
TO THE OIL INDUSTRY

Service
Anywhere Anytime

New Services • • • New Tools • • • New Methods • • • Outstanding Results

Magna Tector/Chemical Cutter Recover 8905 Feet of Tubing

McCullough Magna-Tector and Chemical Cutter Recover 569′ of Tubing Below Stuck Point Shown by Instruments of Another Make

A free point locator was run in this Wyoming well, by another service company, to find the free point in a stuck string of 2½″ tubing. Instrument readings showed the tubing stuck at 8350′.

Operator was not satisfied and called McCullough to verify the lowest free point with the Magna-Tector.

Magna-Tector showed the tubing to be free at 8919′. McCullough's Chemical Tubing Cutter was run and a cut made at 8905′.

Due to the accuracy of the Magna-Tector in locating the lowest free point and the efficiency of the Chemical Cutter in cutting the tubing at the required location, the operator recovered all free tubing in one run of Chemical Cutter.

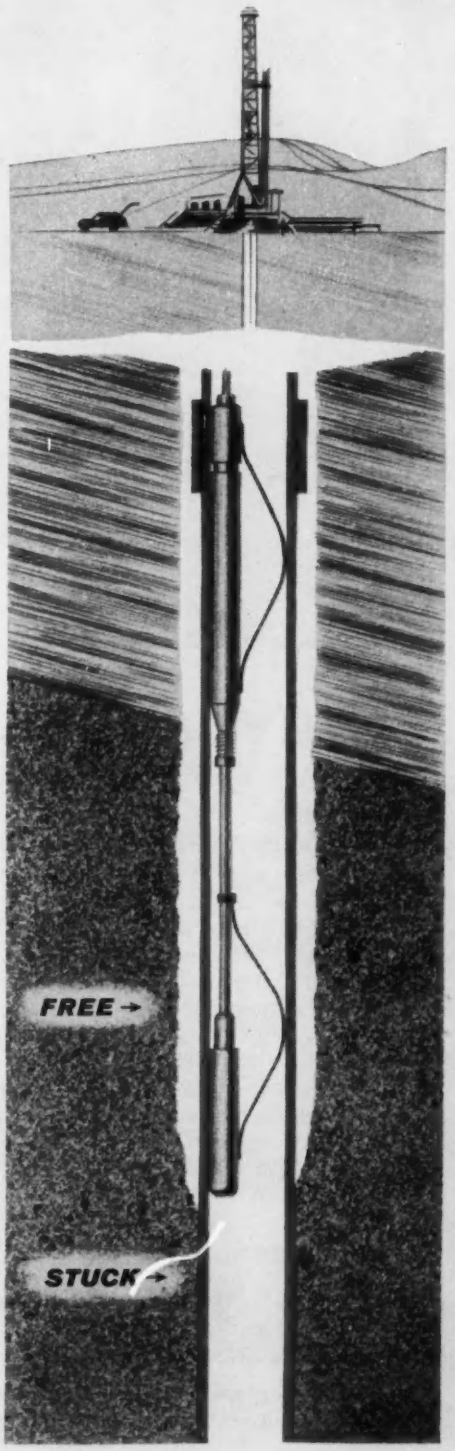
The entire job required only 4½ hours to complete, resulting in substantial savings in rig time and in costs that would have been required to remove the additional tubing by other methods.

The job shown above is certified to be a true field report of service rendered.

ACCURACY OF MAGNA-TECTOR HELPS RECOVER *ALL* FREE PIPE

When pipe is stuck, call for McCullough's Magna-Tector (Free Point Finder). Locates lowest free point, accurately and in a hurry. Paves the way for fastest recovery of all free pipe and speeds up remaining fishing operations. You save money, rig time and recover more pipe. Used in drill pipe, tubing and casing.

Ideal companion tools of the Magna-Tector—McCullough's String Shot Back-Off Tool, the Chemical Tubing Cutter, and Jet Casing Cutter. McCullough Service Engineers will give you full information and recommend the proper tool for your particular job.



McCullough® TOOL COMPANY

Cable Address: MACTOOL

LOS ANGELES
HOUSTON
EDMONTON

For more data on advertised products, use Readers' Service Cards, last page.

"HEY! MIKE...

tell 'em up at the office we made schedule — bang on the nose! And Mike, do me a favour. Mail my regards to the guys who built that diesel. We could do with a lot more of 'em around here!"

Already, oilmen are experiencing the superior power service given by the new Ruston air-cooled diesels... the most advanced power units of their type . . . diesels with built-in stamina, traditional to Ruston manufacture. Extremely adaptable for all small-power applications in the oilfields, these diesels are superb in performance and their maintenance is child's-play. Every Ruston diesel goes into the field with a proved record of absolute reliability. Its prototypes have undergone the most comprehensive tests in one of the world's most modern engineering research centres . . . in temperatures ranging from –40 to 130°F and in conditions ranging from ideal to the impossible. Your plant will have *real* staying power if it's Ruston-powered.

RUSTON **air-cooled diesels**
4-87 b.h.p.

The power units backed by a first-class world-wide spares service to give you complete dependability.

RUSTON & HORNSBY LTD. · LINCOLN · ENGLAND
Associated with Davey, Paxman & Co. Ltd., Colchester, England

Representatives for Petroleum Industries: Beckley, Haltom & Hickman, The Americas Building, Rockefeller Center, 1270 Sixth Ave., New York 20, N.Y., U.S.A.

WORLD OIL

"Wow, look at that terrific rotating speed! . . . Must be tough on the joints."

Where're You Going?

A man spends the first 20 years of his life having his mother ask where he is going. Then the next 40 years his wife does the same. Even when he dies, his pallbearers wonder the same thing.

Definition

The pretty young teacher was explaining the difference between abstract and concrete.

"Concrete means something you can see," she told the children, "and 'abstract' means something you can't. Now who will give me an illustration?"

Little Tommy in the first row was the first to hold up his hand. "My pants are concrete," he said, "Yours are abstract."

Texas Quips

A Texan had a small farm with just a few sheep. One day his wife while dyeing some bedspreads blue had a little lamb fall into the bucket of dye. A passing motorist saw the lamb with the blue fleece and bought it for $50. So the Texan figured he had a good thing going and colored more lambs which brought big profits.

"Pretty soon," he recalled, "I was coloring them pink, blue, yellow, green, lavender and you know—now I'm the biggest lamb dyer in Texas."

SECONDARY RECOVERY
Since 1922

PETROLEUM ENGINEERS
CABLE & STEPHENS
WICHITA FALLS, TEXAS

RESERVOIR ENGINEERING
Water Flooding **Gas Repressuring**
EVALUATION **CORE ANALYSIS**
SURVEYS **ECONOMICS**
Cost Estimates, Design, Installation
FIELD SUPERVISION
Phone 723-2167

WHO'S MEETING WHERE

NOV. 6– 7	AAPG Pacific section, Annual Meeting, Los Angeles.
10–13	API 38th Annual Meeting, Chicago, Conrad Hilton, Palmer House and Congress Hotels.
21–22	"Legal Problems in the Tidelands" Study Program, Tulane University, New Orleans.
DEC. 5	ASME, Annual Meeting, New York City, Statler & Sheraton-McAlpin Hotels.
9–10	Petroleum and Chemical Industry Short Courses, Credit Management for the Petroleum Equipment and Service Industry, The University of Oklahoma, Downtown University Center, Lockett Hotel, Norman, Okla.
1959 FEB. 2–27	Southwestern Legal Foundation, Short Course on Oil and Gas Law, Southwestern Legal Center, Dallas.
11–13	Southwestern Legal Foundation, 10th annual institute on the Law of Oil, Gas and Taxation, Southwestern Legal Center, Dallas.
15–19	AIME, Annual Meeting, San Francisco, Hotels St. Francis, Sheraton-Palace, Sir Francis Drake.
24–25	Geological Symposium, The University of Oklahoma, Norman, Okla.
MAR. 4– 6	API Division of Production, Southwestern District, Scharbauer Hotel, Midland, Texas.
17–21	NACE, National Meeting, Civic Auditorium, San Francisco.
31– Apr. 2	Power Conference, Illinois Institute of Technology, 21st American Power Conference, Hotel Sherman, Chicago.
APRIL 5– 9	Nuclear Congress, Engineers Joint Council, Cleveland, Ohio.
8–10	API Division of Production, Eastern District, Spring Semi-Annual Meeting, Penn-Sheraton Hotel, Pittsburgh, Penn.
20–24	Petroleum & Chemical Industry Short Courses, Safety Engineering, University Downtown Center, Lockett Hotel, the University of Oklahoma, Norman, Oklahoma.
22–24	API Mid-Continent District Meeting, Herring Hotel, Amarillo, Texas.
26–28	TIPRO, 14th Annual Meeting, Baker Hotel, Dallas.

Nomads' Chapter monthly meeting: Los Angeles, second Wednesday, Jonathan Club, Wallace A. Sawdon, Secretary. Houston, second Monday, Ye Old College Inn, Harry E. Estes, Secretary. Dallas-Fort Worth, first Monday, Greater Dallas Club, Hank Davis, Secretary. Tulsa, Hotel Tulsa, Gilbert Swift, Secretary. New York, first Monday, Hotel Biltmore, Jesse E. Hickman, Secretary.

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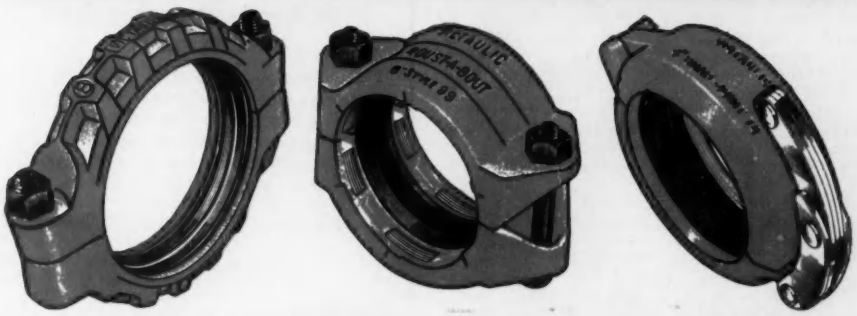
METHOD OF PIPING

VICTAULIC HAS EVERYTHING...



VICTAULIC COUPLINGS
Simple, fast, reliable. *Styles 77, 77-D,* for standard uses with steel or spiral pipe, — *Style 75* for light duty. Other styles for cast iron, plastic and other pipes. Sizes ¾" to 60".

ROUST-A-BOUT COUPLINGS
For plain or beveled end pipe *Style 99*. Simple, quick, and strong. Best engineered and most useful plain end coupling made — takes a real "bull-dog" grip on the pipe. Sizes 2" to 12".

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The new, boltless, speed coupling, *Style 78*. Hinged into one assembly for fast piping hook-up or disassembly. Hand locks for savings in time and money. Ideal for portable lines. Sizes 1" to 8".

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VICTAULIC FULL-FLOW FITTINGS
Elbows, Tees, Reducers, Laterals, *a complete line*—fit all Victaulic Couplings. Easily installed — top efficiency. Sizes ¾" to 12".

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Time saving, on-the-job grooving tools. Light weight, easy to handle — operate manually or from any power drive. Sizes ¾" to 8".

PLUS FITTINGS AND GROOVING TOOLS

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Promptly available from distributor stocks coast to coast.
Write for NEW Victaulic Catalog-Manual G-11

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For more data on advertised products, use Readers' Service Cards, last page.

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RATES: Regular Classified (undisplayed) set in this size type: 20 cents per word. Minimum charge $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border, $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All classified ads payable in advance.** Send copy and checks to: Trading Post Classified Section, World Oil, P. O. Box 2608, Houston, Texas.

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■ American engineer established Monte-Carlo wishes representation oil industries & materials—Apply Havas Monte-Carlo 2959—

■ Make $150 a week at home, spare time. A great opportunity. General Manager, Lambert Distributors, 518 Richards St., Vancouver 2, B. C. Canada.

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■ Desire associate to make and sell L A C T and Desander Equipment Gulf Coast. Box 175-W, WORLD OIL, Houston, Texas.

■ Wildcatting? Nine producers in ten tries. New Geology. Analysis anywhere. Hehr, 12300 Ohio Avenue, Los Angeles, Calif. GRanite 7-9741.

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Wanted engine driven compressors 500 to 1000 H. P. I R, Clark, Cooper-Bessemer—dual fuel or Diesel. Reply care box 176-W WORLD OIL, HOUSTON, TEXAS.

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3600'–7" 23#–LT&C–N-80, R-3
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NAT. 130 DRILLING RIG
FOR IMMEDIATE SALE IN COLOMBIA

One complete Nat. 130 rig, with all normal auxiliary components. Six years old and has drilled total 118,000 ft. Rig is in sound operating condition. Sale will be made by bid only. All inquiries and replies should be addressed to:

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8—8" OD Drill Collars
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For further information call Hobbs, New Mexico—EX 3-4594

WORLD OIL

"He oughta know what he's doing —he's the driller."

Boss's Orders

An executive who is a great believer in efficiency hung up a sign in his office one day last week. It read: "Do It Now."

Within 24 hours, the cashier bolted with the contents of the safe, his stenographer eloped with his eldest son, the office boy threw the ink bottle into the electric fan, and the whole office force took the afternoon off.

That's Gratitude

"Aren't you ashamed," the judge asked the man, "to have your wife support you by taking in washing?"

"I am, your honor," he replied, "but what can I do? She's too ignorant to do anything else."

Title for Successful Book

"How to Get Out of Doing It Yourself."

Screenitis

Many a television program would have a happier ending if we just had the energy to get up and turn it off sooner.

Personnel to Applicant

"What we're after is a man of vision; a man with drive, determination, fire; a man who never quits; a man who can inspire others; a man who can pull the company's bowling team out of last place!"

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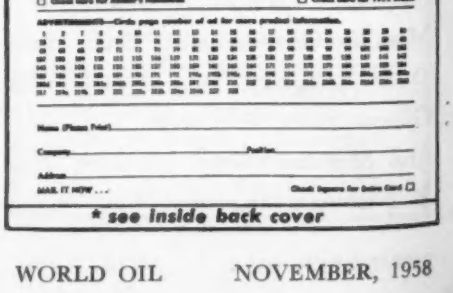
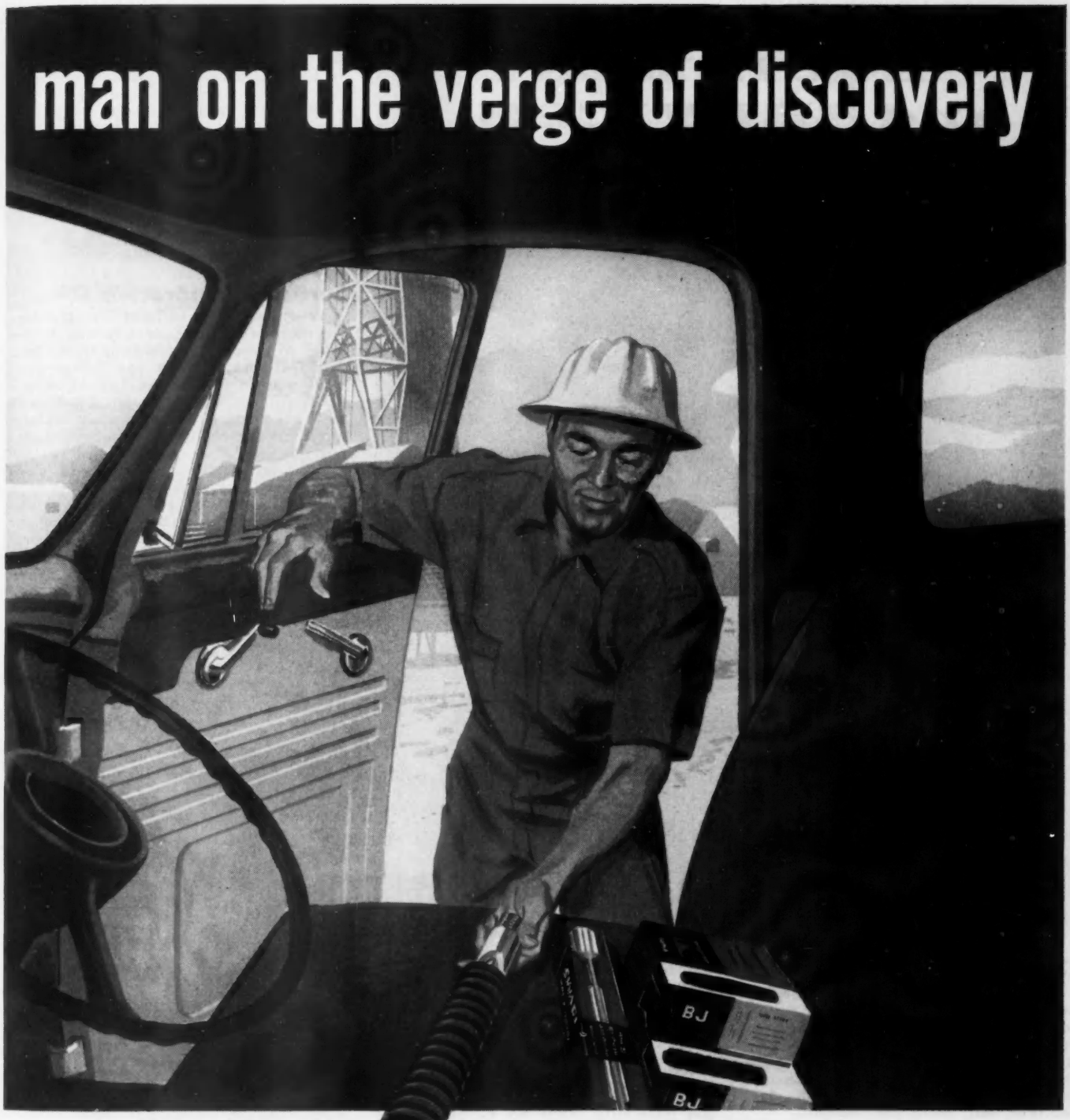


* see inside back cover

man on the verge of discovery



BJ swabs

He's already discovered that Byron Jackson's new swabs cost less because they require fewer parts and accessories to accomplish more kinds of swabbing jobs.

Before the day is over he'll discover that BJ swabs put more fluid in the tank, in less time, with fewer rubber replacements.

BJ swabs pull the greatest possible loads — yet their exclusive flexible feature allows them to adjust to light or medium loads, too.

You get a choice of cup-type or disc-type rubbers. Two of either kind fit on the streamlined body. Your supply store has BJ swabs in stock. The investment is small; discover them for yourself.

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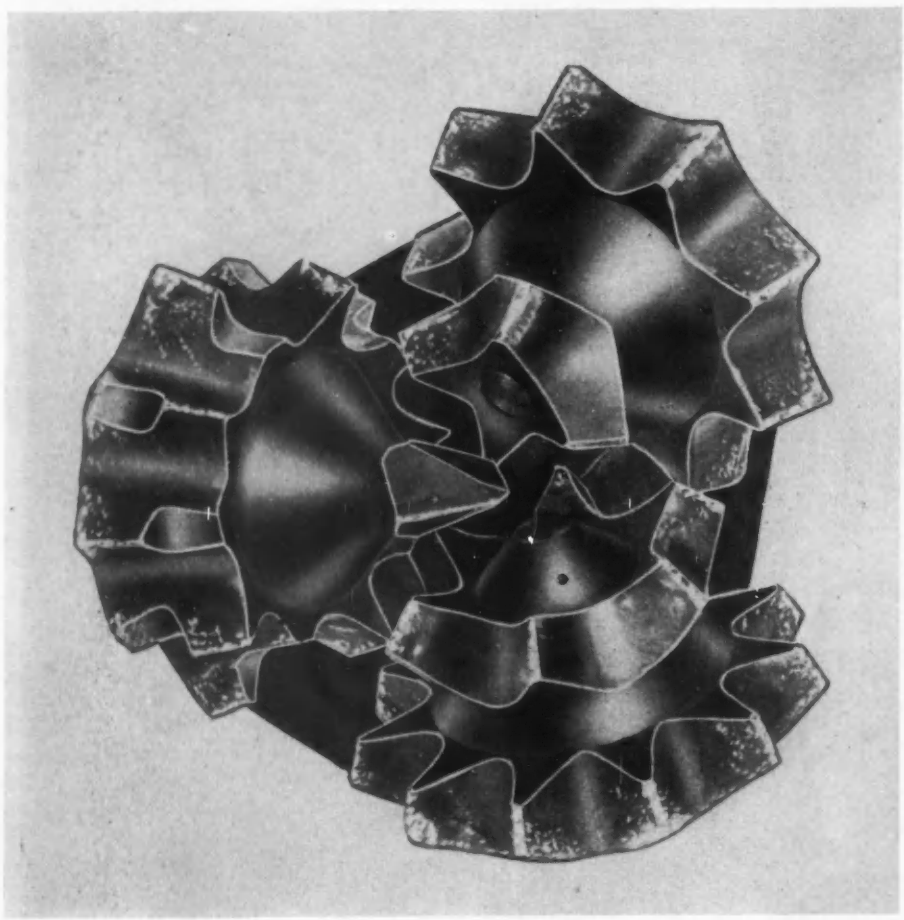
What's New in EQUIPMENT and SERVICES

Drilling - Production - Exploration



Gouging Bit

Oil Tool Manufacturing Co., Inc., announces a new bit to economize drilling costs. Designated as the K-4, this bit features an exclusive design with long, strong teeth which deliver maximum penetration in such low compressive strength strata as soft shales, broken shale, clays, red beds, salt, shells and limestone.

To gain a tearing, gouging action without heavy weights, the cones are offset 6 degrees from the apex. All bits are heat-treated in the latest deep carburizing furnaces to insure uniformity, reduce distortion and deliver bright scale-free finish.

(This item supplements Oil Tool Manufacturing Co. data on Pages 3874 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E1** on Readers' Service Card, last page this issue.

Junk Mills

The Servco line of junk mills, now used for milling up rock bits, reamer blades, hard-faced tool joints and for most other clean-out jobs, has been further improved by the addition of four wear strips on the body of the tools. This feature prevents damage to the casing during the milling operation.

Cutting blades have also been "beefed up" with heavier webbs of Servcoloy, a new hard-facing material developed by Servco. This patented material utilizes a unique method to suspend chunks of carbide in a tough, resilient matrix. The matrix acts as a shock absorber overcoming carbide's inherent sensitivity to shock, and permitting its use in even the most rugged downhole conditions. Suspending hundreds of chunks in the matrix assures a continuous exposure of sharp cutting edges to the work.

(This item supplements Servco Co. data on Pages 4697-4720 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E2** on Readers' Service Card, last page this issue.

Tool Joint Compound

Mr. 'B is the name of a new low-cost tool joint compound recently introduced by I. H. Grancell Co., manufacturers of the 'Bestolife No. 270 compound.

Mr. 'B, is a high quality lead base thread lubricant designed specifically for tool joints. It is said to incorporate many of the 'Bestolife features, provides economical thread protection, prevents galling and seizing and is strongly resistant to corrosive action.

For more data, circle **No. E3** on Readers' Service Card, last page this issue.

Surface Restorative

Newly galvanized surfaces damaged during transportation or erection can be restored to the original condition in the field with Galvanox, a paint now being extensively marketed by Subox, Inc. When applied with an ordinary paint brush at 4 to 5 mil thickness, it is said to conform to ASTM specifications for hot dip galvanizing.

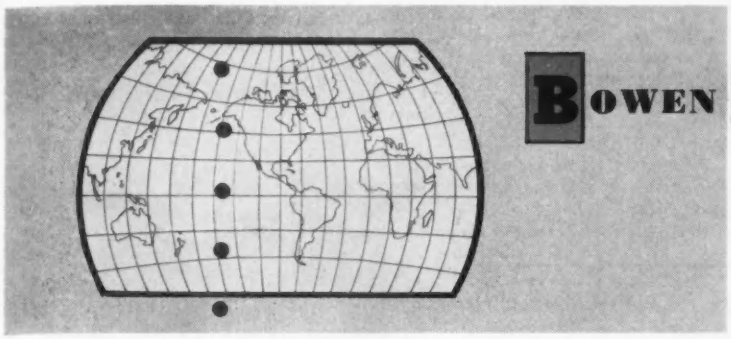
Galvanox is different from zinc dust-zinc oxide paints. Galvanox contains a high percentage of metallic zinc in an organic binder. It forms a film that is almost entirely zinc and gives an electro-chemical type of protection long associated with galvanizing.

For more data, circle **No. E4** on Readers' Service Card, last page this issue.

Lubrication Alarm System

A new protective device for use on force-feed lubricating systems has been announced by Manzel, a division of Houdaille Industries, Inc.

The new product, called the Lube-Line Alert, is installed at each terminal point of lubrication simply by cutting the line and connecting the fittings. The unit is



BOWEN ITCO, INC.

And its **S.R. BOWEN** *Division*

AROUND THE WORLD

BOWEN • ITCO'S

PACKER RETRIEVER

POSITIVE CATCH · CONTROLLED RELEASE

Though it is one of our most newly developed tools, the Bowen Itco Packer Retriever is already gaining wide acceptance and favorable acclaim in the field, as a dependable, prime means of loosening and pulling "Drillable" Production Packers.

Operation The Packer Retriever, made up to the fishing string, passes through the Packer and continues through the bottom. A specially designed Rotary Shoe, made up in the string above the Retriever, cuts the Packer's Slips and Sealing Element. The Packer Retriever is then raised until the Upset on the slotted portion (Cage) contacts the Seat in the bottom of the Packer and with subsequent pulling and/or jarring will free the Packer so that it may be withdrawn from the well.

Features In addition to doing the job of pulling Packers precisely as it was designed to do, the Bowen Itco Packer Retriever offers several safety features which cover almost any problem which might arise.

1. Is provided with a small circulation bore to allow high velocity jetting so important when attempting to enter a Packer which has become sanded over.
2. Provides means for releasing from the Packer at any time, in the event the Packer should jam or cannot otherwise be pulled.
3. A built-in spring stop prevents the possibility of losing the Packer during the pulling operation.

Write for the new **BOWEN ITCO** ***PACKER RETRIEVER*** *brochure*

DOMESTIC / EXPORT

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BOWEN ITCO
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HOUSTON 13, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

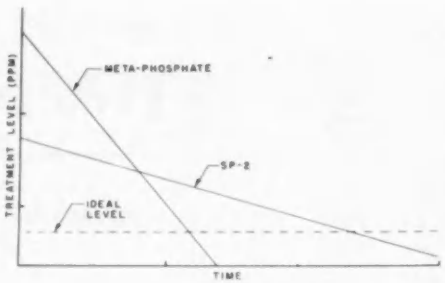
then connected electrically to any desired audio, visual or mechanical warning device. If the flow of lubricant through the unit is interrupted for any reason, the signalling system is activated. This may be a bell, whistle, horn, master controlboard light or a relay to shut off the motor or ring a telephone.

For more data, circle **No. E5** on Readers' Service Card, last page this issue.

Scale Inhibitor

Costly scale deposits can now be brought under more effective control with Halliburton Oil Well Cementing Co.'s Scalechek. This new service uses SP-2, a scale-checking compound, to inhibit scale crystallization in and on formation faces and tubular goods.

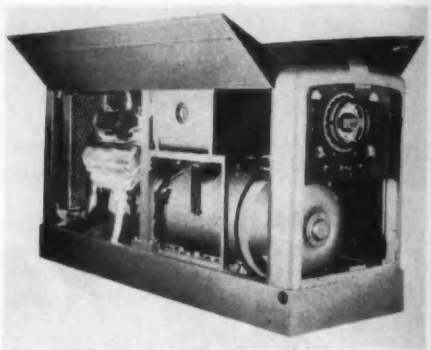
SP-2 provides longer protection because



of its higher P_2O_5 content, slower solubility and closer particle size distribution. Placed in the formation in combination with fracturing sand or with oil alone, SP-2 conditions the water in and around the pay zone to check crystal growth.

(This item supplements Halliburton Oil Well Cementing Co. data on Pages 2165-2284 of the Composite Catalog, 22nd Edition).

For more data, circle **No. E6** on Readers' Service Card, last page this issue.



Heavy Duty Welder

A new 600-ampere DC heavy duty welder for arc and stud welding is available from Hobart Brothers Co. with either a gasoline or Diesel engine power source.

The welder is rated 600 amperes, 40 volts on 60 percent duty cycle. Welding current range is 70 to 800 amperes, and 1 kw auxiliary power of 110 volts DC is available while welding.

The gasoline engine driven model GM-618-S is powered by a Chrysler IND-56A V-8 engine with 354 cubic inch piston displacement.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

Bulk Cement Trailer

A bulk cement trailer custom designed to operate in the oil fields of the Near East is manufactured by Rig Engineers and Fabricators Co., to haul bulk cement over desert terrain. The trailer consists of two twin screws driven by 30 horsepower motor, on heavy trailer suspension with 14:00 by 20 tires.

Trailers similar to the one pictured or trailers or trucks which unload by pneumatic means, to handle practically all dry and granular material, are also manufactured.

(This item supplements Rig Engineers & Fabricators Co. data on Pages 4546-4553 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E8** on Readers' Service Card, last page this issue.

Motor Valve

Enardo Manufacturing Co. is marketing a new motor valve specially designed for use in lease automation.

The 2-inch valve is of the three-way, two-position motor type. Of simple, rugged construction, it is tested to 150 pounds

WHY TOLERATE

— Rapid Wear Of Kelly & Kelly Bushings?

— Friction Hold Up Between Kelly & Kelly Bushings?

— Excessive Wear In Drive Squares?

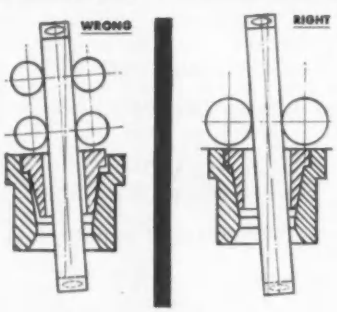
— Kelly Kinking?

VARCO

THE SELF COMPENSATING ROLLER KELLY BUSHINGS PROVIDE PERFECT INTERACTION BETWEEN THE SWIVEL AND THE ROLLERS OF THE BUSHING!

If the Crown Block is slightly off center—the Traveling Block swings due to wind or other adverse conditions—the Derrick leans or the Drill Pipe hugs the side of the hole, it is necessary to have a Drive Bushing which will compensate for such errors.

The superior design of VARCO ROLLER KELLY BUSHINGS provides perfect interaction for the Swivel and the Rollers of the Bushing. The Rollers, being located on one level, act not only as a driving mechanism, but also as a guide to the Kelly Stem, and in no way interfere with the constantly moving swivel due to unfavorable working conditions or location. The Swivel, being in reality a universal joint, is unencumbered in its motion. This eliminates friction and prevents bind on the Kelly. The Kelly stem follows the Drill Stem freely and as the bushing revolves smoothly, and noiselessly in the table the Kelly is not restricted.



You'll like these additional advantages of

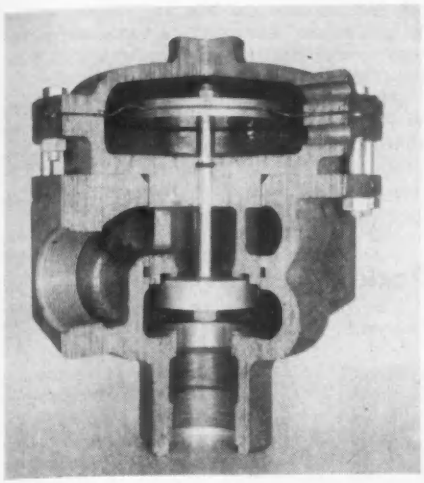
VARCO ROLLER KELLY BUSHINGS

• One Varco Roller Bushing Body is adaptable to all types and sizes of Kellys • Rollers mounted on Roller Bearings fully envelop the Kelly • VARCO Roller Kelly Bushings, with exposed Rollers, can be completely washed of mud • VARCO Roller Kelly Bushings always remain in the table when reaming, drilling up, or jarring.

SEE OUR SECTION IN THE COMPOSITE CATALOG OR WRITE FOR NEW CATALOG

Abegg and Reinhold Co.

2533-2541 East 26th Street, Los Angeles 58, Calif.
HOUSTON, TEXAS • OKLAHOMA CITY, OKLAHOMA



per square inch pressure, and all working parts are removable without disturbing the piping. The body and inner valve parts are corrosion resistant. Molded Hycar seating surfaces insure a positive seal.

(This item supplements Enardo Manufacturing Co. data on Pages 1691-1694 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

Seismic Reference Service

A seismic reference service has been added by Schlumberger Well Surveying Corporation to its list of well logging and auxiliary operations. The service was initiated in the Permian Basin recently and will be extended to other regions as justified by the demand. This package velocity service provides complete velocity data for both well evaluation and geophysical exploration in the well vicinity. It combines the Schlumberger Sonic Log, introduced during the past year, with seismic check shots between levels in the borehole and the surface.

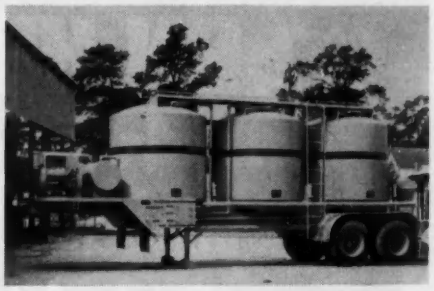
The seismic velocity measurements are performed by Century Geophysical Corporation as subcontractor. Seismic equipment is supplied by Century Geophysical Corporation with the Schlumberger field unit being used for operations in the well. The seismic reference service provides complete handling of the entire operation—sonic logging, obtaining necessary permits for seismic shooting, surface surveying, shothole drilling, shothole velocity recordings, well geophone, recordings and comprehensive computation of results.

(This item supplements Schlumberger Well Surveying Corp. data on Pages 4621-4652-L of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

Bulk Cement Trailer

Rig Engineers and Fabricators Co., Inc., has available a custom designed pneumatic bulk cement trailer for transporting bulk cement from the plant to the job site.

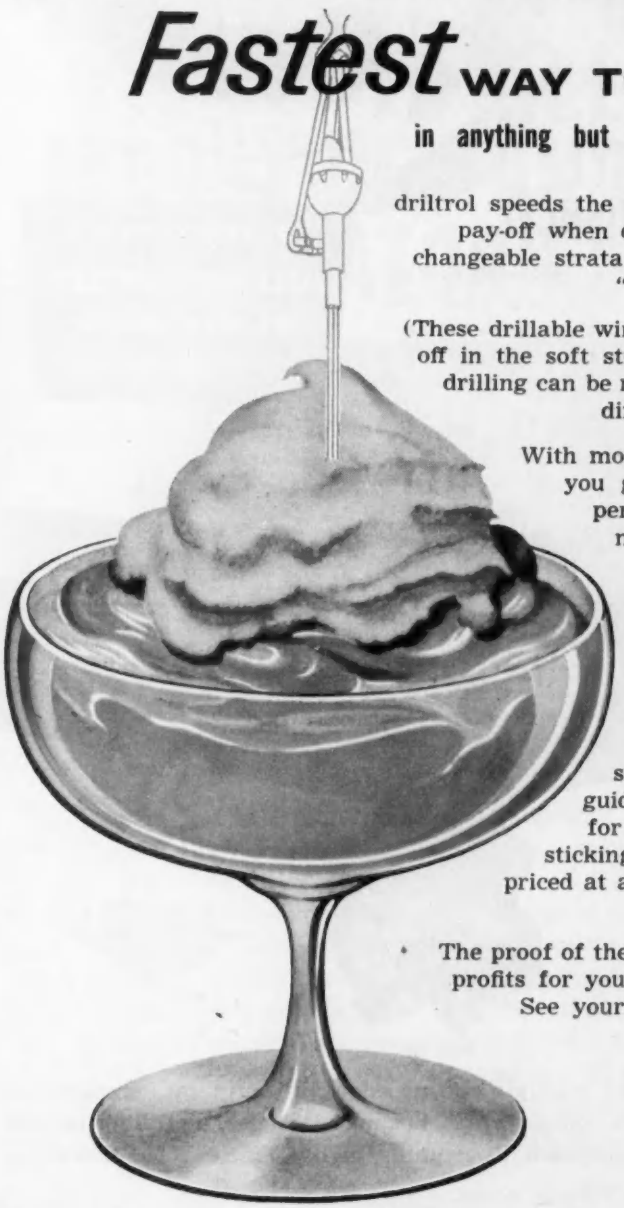


After arrival at the job site, the truck is capable of unloading its cargo by pneumatic means into storage bins approximately 50 feet high.

Additional equipment usually required to elevate the material is not needed. All controls are located in a central panel at

Fastest WAY TO PAYOFF

in anything but butterscotch pudding



driltrol speeds the time from spud-in to pay-off when directional drilling or changeable strata cuts you out of the "soft-as-pudding" jobs.

(These drillable wing stabilizers can pay off in the soft stuff, too, because fast drilling can be maintained only when direction is controlled.)

With more weight on the bit, you get faster, controlled penetration. And, when necessary, washover is a matter of *minutes!*

More than 25,000 driltrol stabilizers have *speeded* drilling all over the globe; *controlled* drilling as fulcrums, hole straighteners, key seat guides, and preventatives for pressure differential sticking. Sized to fit your job, priced at about half the cost of a single drill bit!

The proof of the pudding is increased profits for your drilling operations. See your driltrol man NOW!

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on your 4-wheel drive stop front end drag in 2-wheel drive!

APPROVED Jeep EQUIPMENT

Models for all makes of 4 w. ds. to 1½ tons at dealers. Write for literature.

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Save on repairs, tires, gas... get new pep, handling ease... with Warn Hubs, the original "selective drive." You'll be way ahead with either automatic LOCK-O-MATICS, or fingertip control Warn Locking Hubs. Unconditionally guaranteed.

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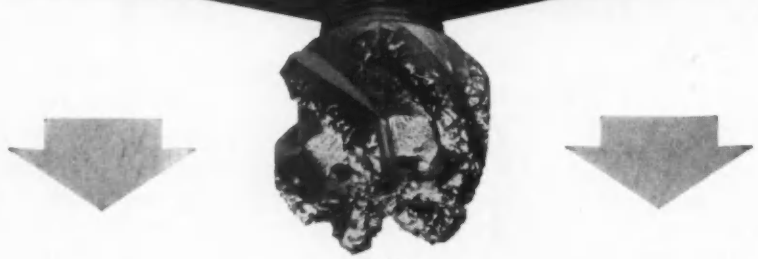
WARN MANUFACTURING CO., Inc. Riverton Box 6064-WO11, Seattle 88, Wash.

WHIP DOWNHOLE MILLING COSTS WITH KINZBACH SPEEDMILLS



TYPE 155

Continuously renewed multiple cutting edges, in optimum arrangement with tool shape, work contact areas, flushing passages, and other factors combine to make Kinzbach Speedmills highly efficient for downhole metal cutting operations.

Kinzbach Speedmills cut rapidly, leave clean work surfaces, and may be run under severe weight and speed conditions.

Types available for every downhole milling problem.

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P. O. Box 277 • HOUSTON, TEXAS
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KINZBACH TOOL CO INC

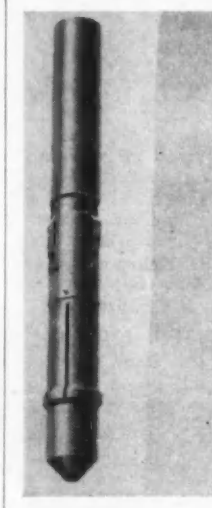
the base of the first bin, for simple operation. Trailers like that pictured were recently exported to a South American construction company.

(This item supplements Rig Engineers & Fabricators Co., Inc., data on Pages 4546-4553 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

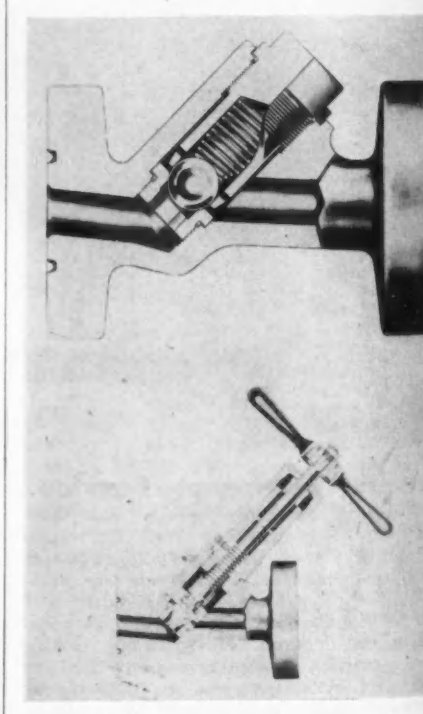
Packer Retriever

The packer retriever, a new tool in the Bowen ITCO line is a strong, versatile and easy-to-operate retriever designed for one trip recovery. It will pass through the bore of the packer in catching position and provides protection against loss of packer during milling operation. It will pull the packer after it has been sufficiently milled over; release from the packer in the hole, if necessary; reset to catch in position. All of these advantages are possible without coming out of the hole. It is made from alloy steel.



(This item supplements Bowen-Itco data on Pages 773-848 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E12** on Readers' Service Card, last page this issue.



Stop and Check Valves

A line of stop and check valves with ratings to 10,000 psi, WOG, is being introduced for oil field producing and gathering lines by Edward Valves, Inc., subsidiary of Rockwell Manufacturing Company.

Higher pressure designs feature high-

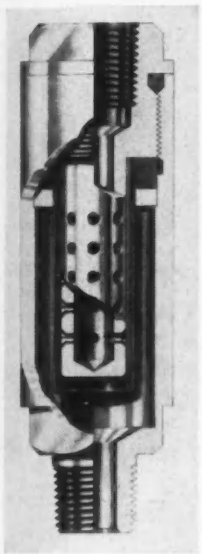
strength body materials and combination metal gasket and rubber O-ring seals to assure tight bonnet and seat joints. The stop and check valves are available with screwed ends or socket welding ends in sizes from ¼ to 2 inches. API standard flanged-end models are available in the 2-inch size only.

(This item supplements Edward Valves, Inc., a subsidiary of Rockwell Manufacturing Co., data on Pages 1606-1609 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E13** on Readers' Service Card, last page this issue.

Auxiliary Check Valve

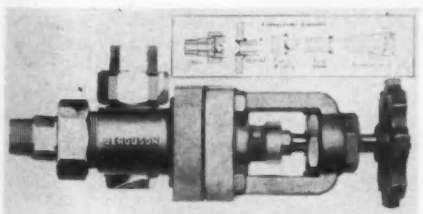
The Macco Oil Tool Co., Inc., normal closed auxiliary check is a 5,000 psi working pressure valve which is manufactured with ½-inch pipe thread connections. It consists of a resilient hycar sleeve built around a ported mandrel tube and enclosed by a stainless steel or monel valve body. When back pressure is applied, the hycar sleeve seals off the ports in the mandrel tube, preventing any possible backflow.



Since the resilient hycar sleeve is the only moving part of this valve it is particularly resistant to the ill effects of abrasive erosion, acid or highly emulsified particles.

(This item supplements Macco Oil Tool Co., Inc., data on Pages 3158-3159 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E14** on Readers' Service Card, last page this issue.



Simplified Bolted Bonnet

Jerguson Gage & Valve Company announces a new, improved type of outside screw and yoke bolted bonnet valve, for use with liquid level gages and instruments.

This new bolted bonnet uses a forged yoke which supports the stem away from the valve body and a separate forged gland-follower which bears directly on the packing and is entirely independent of the yoke. This construction of course places the threaded portion of the stem outside of the valve body where it is not affected by temperature or nature of the liquid being handled. The design allows the valve stem to work freely at all times and prevents possible freezing.

For more data, circle **No. E15** on Readers' Service Card, last page this issue.

HYCALOG

PRECISION-HYCALOG CHRONOFRAC Patent Pending IS NOW AVAILABLE TO ALL INDUSTRIES AND LABORATORIES

CONTINUING RESEARCH FOR LOWER COST EXPLORATION

This sensitive automatic gas analyzer, developed by HYCALOG's researchers, is now manufactured and sold by PRECISION SCIENTIFIC CO., Chicago.

Recommended for any processing operation involving gases, PRECISION-HYCALOG CHRONOFRAC provides continuously repetitive monitoring along with rapid qualitative and quantitative analysis. It is especially valuable in petroleum and chemical plants, research and school laboratories, paint factories, distilleries and food processing plants.

Sales for oilfield and well logging application are handled by HYCALOG; all others by PRECISION SCIENTIFIC.

Write for complete technical information and details on leasing or purchasing.

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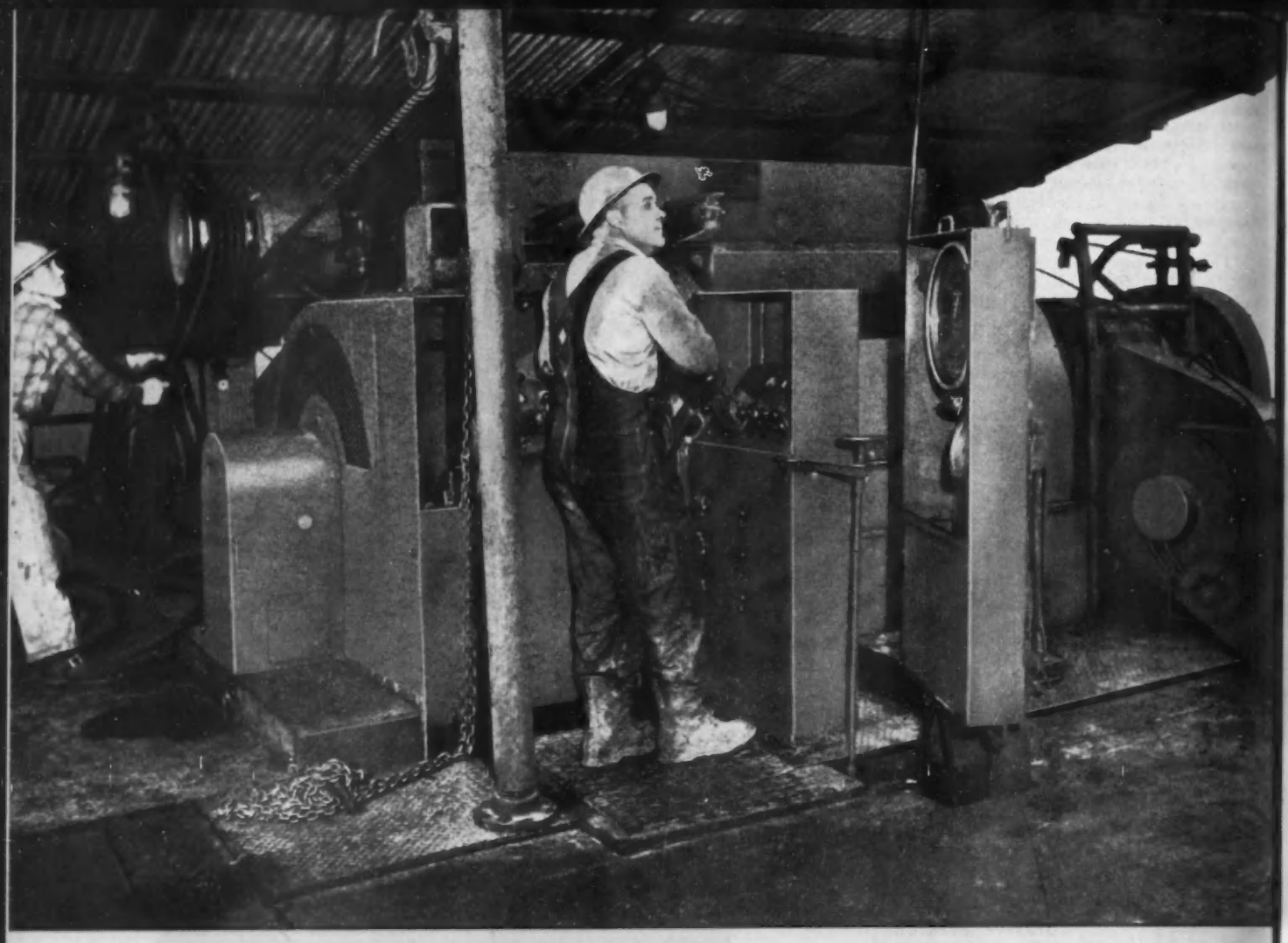


Go deep...go fast with the **BETHLEHEM 1013**

In deep-hole drilling, no other rig outperforms the Bethlehem 1013. It's a heavy-duty rig designed and built to make hole fast.

The 1013 has Bethlehem air friction clutches with a high safety factor, massive shafts, and extra-large water-cooled brakes. Full capacity can be utilized with any type of drive—mechanical, hydraulic torque-converter, hydraulic coupling, electric coupling or electric motor. Engine compounding elements are available for any number of prime movers, and they can be furnished with one or two pump drives. A two-speed pump drive is available.

Bethlehem engineers will gladly supply performance data. Call or write our nearest office.

HIGHLIGHTS OF BETHLEHEM'S 1013 DRAWWORKS

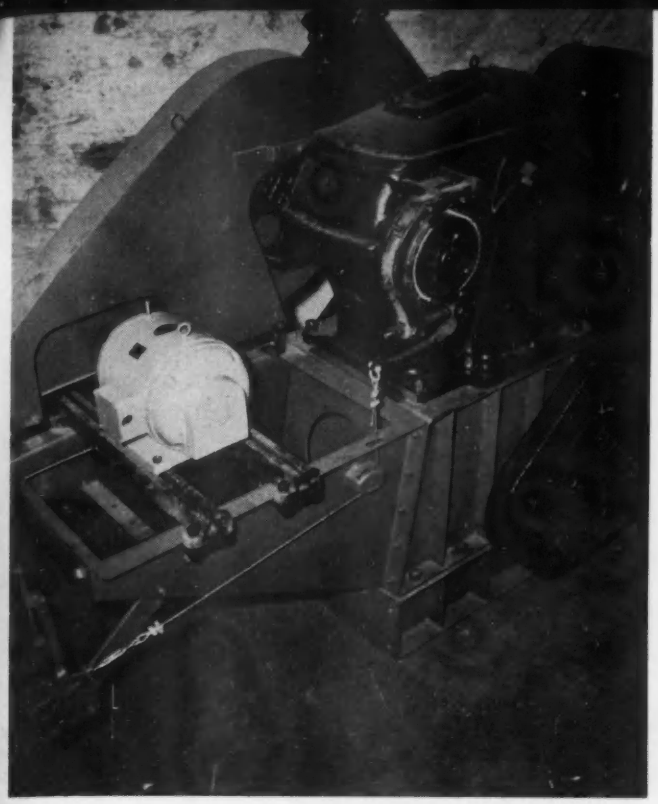
Recommended input hp to transmission	1500*
Number of hoisting speeds	6
Number of rotary speeds	3
Number of reverse speeds	2
Brake rim diam and width, in.	52 x 12½
Arc of brake lining contact, degrees	330
Length of drum spool, in.	50
Diam of drum spool, in.—grooved	28
Low-speed drum clutch working cap., ft-lb	102,000
High-speed drum clutch working cap., ft-lb	59,000
Drum shaft diam, in.	9⅜
Rotary clutch torque cap., ft-lb	16,000
Shaft bearings, type	Self-aligning roller
Upper drum	Optional

*Additional horsepower can be provided to drive mud pumps or auxiliary equipment.

BETHLEHEM SUPPLY COMPANY
General Offices: 21 E. Second St., Tulsa, Okla.
West Coast Headquarters: Los Angeles, Calif.
Canadian Distributor: Bethlehem Supply Company of Canada, Ltd.
Calgary, Alberta, Canada
Export Office: Bethlehem Supply Company (Export Division)
25 Broadway, New York, N. Y.

BETHLEHEM STEEL

BETHLEHEM SUPPLY



Elevated Motor Assembly

The elevated electric motor power assembly has been designed by Bethlehem Supply Company for hazardous locations as well as economy. This assembly affords protection of the electric motor against high water, drifting sand or deep snow difficulties.

The brake lever is mounted at a convenient operating height with its bracket designed as a handy step to reach the elevated power assembly platform. Conversion to any other type of prime mover assembly is easily accomplished by unbolting the elevated assembly from the reducer subbase.

(This item supplements Bethlehem Supply Co. data on Pages 657-684 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E16** on Readers' Service Card, last page this issue.

Correction Record Unit

A correction magnetic record-playback unit designed for both field and office use is now being manufactured by Fortune Electronics, Inc.

The outstanding feature of the unit is its ability to handle any shot spread configuration. Spread length adjustments are calibrated directly in feet. The DC-2 accommodates standard 6½ or 7-inch tapes. The unit weighs only 82 pounds and measures 15 by 18 by 14 inches.

For more data, circle **No. E17** on Readers' Service Card, last page this issue.

what does

$$\triangle F/A = \triangle p$$

mean to you?

(Continued on next page)

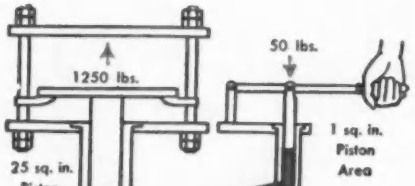
(Continued from preceding page)

$$\triangle F/A = \triangle p$$

. . . is the mathematical expression for Pascal's Principle which states that: "pressure applied to a confined fluid is transmitted uniformly to all areas of the confining fluid."

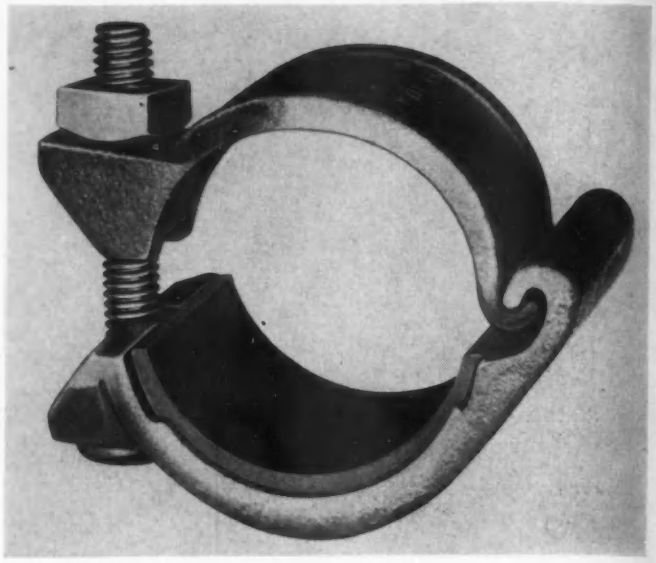
In the drawing below, notice how a relatively small pressure of 50 pounds applied to the 1 sq. in. piston raised 1,250 pounds on the 25 sq. in. cylinder. Pascal discovered how to multiply the muscles of man a thousand fold! Today, the light touch of a woman's toe against a foot pedal smoothly yet quickly slows and halts a two ton automobile.

Pascal's Principle had been known for hundreds of years when a man by the name of Sven Nordstrom successfully applied the principle to



Here is a demonstration of Pascal's Law. A given pressure of 50 lb lifts 1250 lb over an enlarged area of 50 to 1 ratio

create a most unusual innovation in valves—his invention, the lubricated plug valve. In the most elementary terms, this valve is simply an old fashioned plug cock (used since the days of Pompeii) to which Nordstrom ingeniously applied the Principles of Pascal.



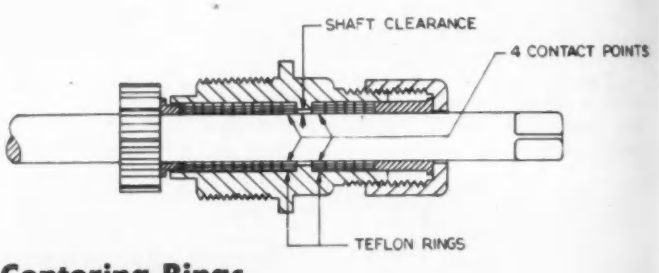
Emergency Pipe Clamp

M. B. Skinner Company has introduced the junior emergency pipe clamp, a companion to the emergency pipe clamp. The junior is made up of single bolt width, instead of two bolt width, and is only 2⅞ inches wide.

Like the emergency pipe clamp, it is made of malleable iron; has a full length hinge along one side, a single oversized plated bolt on the other.

(This item supplements M. B. Skinner Co. data on Page 4817 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E18** on Readers' Service Card, last page this issue.



Centering Rings

Daniel Orifice Fitting Company has announced a design change affecting its junior and senior orifice fittings. Teflon shaft centering rings will be provided to eliminate metal-to-metal contact between shaft and stuffing box. These rings assure free shaft rotation even after long inoperative periods of service.

The Teflon rings are self-lubricating, non-adhesive and inert to most chemicals.

(This item supplements Daniel Orifice Fitting Co. data on Pages 1445-1480 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E19** on Readers' Service Card, last page this issue.

Sturdy Gate Valve

A W-K-M production model gate valve is reported to have "no evidence of leakage" after laboratory investigations.

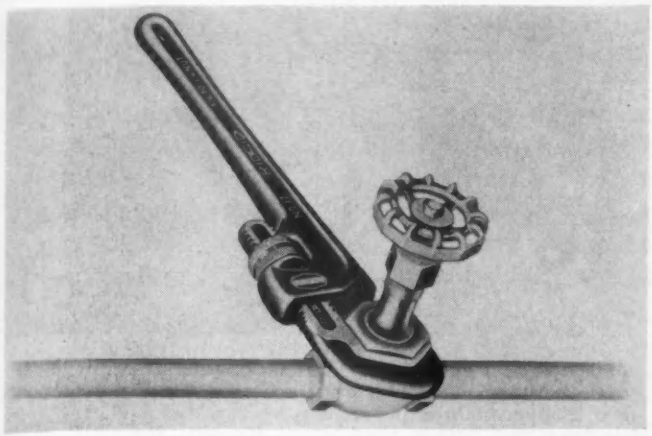
The valve used was a 2-inch, balanced stem through-conduit gate valve with working pressure of 15,000 psi. It utilizes the parallel expanding gate design.

(This item supplements W-K-M Manufacturing Co., Inc., a subsidiary of ACF Industries, Inc., data on Pages 5257-5292-H of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E20** on Readers' Service Card, last page this issue.

Hex Wrench

This new Ridgid hex wrench from The Ridge Tool Company has an adjustable four-sided jaw that's easy to put on or take off. Angular jaw design is said to give more leverage plus time-saving, positive grip on hex nuts, square nuts, valve packing



nuts, unions and gas cocks, rough or finished. Narrow jaws make work easy in tight places.

Comfort-grip I-beam handle, made of special malleable alloy, has handy hang-up hole.

For more data, circle **No. E21** on Readers' Service Card, last page this issue.

Utility Side Boxes

Stahl Metal Products, Inc., all-steel, welded utility side boxes give pick-up trucks, more carrying space, space for tools, parts, pipe, fittings, wire etc. Also, they act as steel sideboards, increasing the bulk loading capacity of pick-up bodies.

Weather-tight, with compartmented bins on the right side and fitted with recessed door handles and cylinder locks, keyed alike, they offer safe, dry storage of valuable equipment.

For more data, circle **No. E22** on Readers' Service Card, last page this issue.

Microwave Package

General Electric Company has introduced a weather-enclosed microwave package designed to extend the life and reliability of communication systems in areas where environment is extremely adverse.

It includes an air-conditioned housing with zinc-coated steel panels, sealed with neoprene. It is pre-stressed and rigidly constructed to stand high wind velocities but still light enough to be airlifted intact for transfer from one communications site to another.

(This item supplements General Electric Co. Electronics Division data on Pages 2019-2020 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E23** on Readers' Service Card, last page this issue.

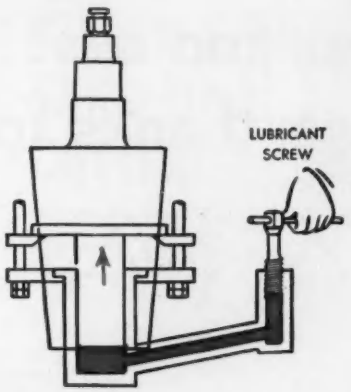
High Pressure Valves

Direct solenoid operated "Shear-Seal" valves available from Barksdale Valves for pressures up to 3,000 psi are now available for operation on 12, 24 or 125 volts D.C. They come in either standard or explosion-proof solenoid housing.

Valves are available in four-way, three-way, shut-off and diverter flow patterns.

These valves feature a self-alignment sealing ring in direct

The perfect application of a principle



The lubricant system in the Rockwell-Nordstrom valve is a closed hydraulic system acting much like the two pistons shown on the facing page. Instead of having a separate piston to "charge" lubricant into the valve, the screwed lubricant fitting at the top of the plug acts as the first piston. When lubricant is forced through the fitting by a pressure gun or if the lubricant screw is manually turned down, hydraulic force is magnified and forces lubricant through the channels in the plug.

The plug then acts in much the same fashion as the second piston. A shot of lubricant from a pressure gun or a few turns of the lubricant fitting minutely unseats the plug upwards against the resilient shoulder seal, freeing the plug for smooth, easy turning.

(Continued on next page)

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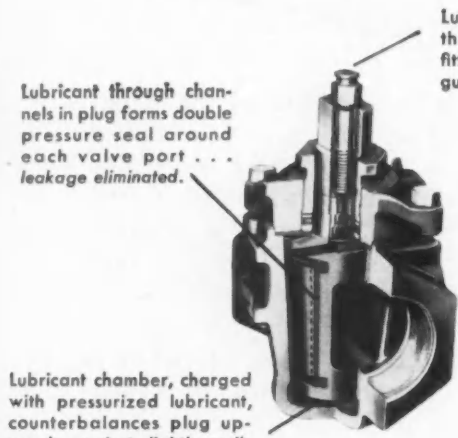
Here's why Rockwell-Nordstrom valves work better, easier and cost less to use, thanks to

$$\triangle F/A = \triangle p$$

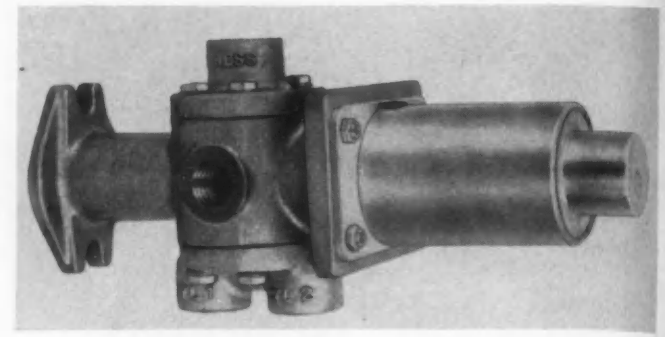

Lubricant injected through Rockwell fitting by pressure gun.
Lubricant through channels in plug forms double pressure seal around each valve port . . . leakage eliminated.
Lubricant chamber, charged with pressurized lubricant, counterbalances plug upwards against slightly resilient shoulder seal. Plug can't be stuck in seat . . . instant, dependable operation.

The drawing above shows how lubricant in Rockwell-Nordstrom valves assures the bottle tight shut-off, smooth, easy operation and unmatched dependability that users have learned to expect over the past forty years. Rockwell-Nordstrom, the *original* lubricated plug valve, is also the world's most complete line. They cost no more to buy, often less, than ordinary valves. Whatever your valve needs, there is a Rockwell-Nordstrom valve that will do the job better, longer and at lower cost. If you'd like to know more about these valves or if you'd like to talk with a Rockwell field sales engineer, write Rockwell Manufacturing Company, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.

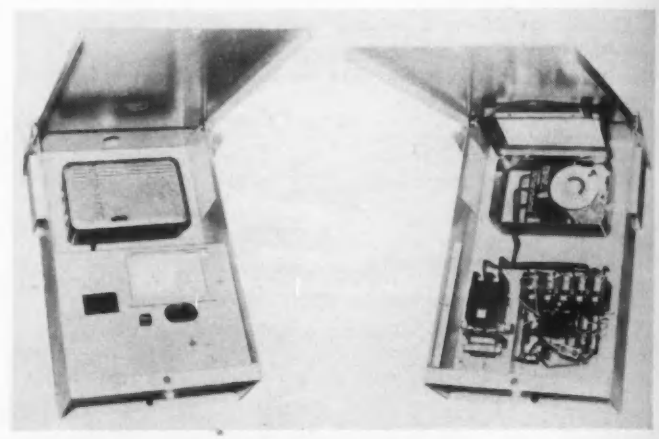
ROCKWELL-Nordstrom VALVES

it's ROCKWELL

MANUFACTURING COMPANY



contact with a mating slide. Metal to metal sealing surfaces continue to lap themselves with each operation thus maintaining their sealing qualities indefinitely.
For more data, circle **No. E24** on Readers' Service Card, last page this issue.



All-Weather Oil Well Panel

An all-weather oil well panel, which provides precision pumping through automatic control, has been announced by Federal Pacific Electric Co. Engineered for performance under all conditions, the device features all-steel construction and is suitable for installation in any location.

Designed for use with single phase pumping units up to 5 horsepower at 220 volts, or 2 hp at 110 volts, 60 cycle operation, the new panel is particularly adapted for the control of shallow oil well pumps.
For more data, circle **No. E25** on Readers' Service Card, last page this issue.

Electric Log Slide Rule

A compact, new slide rule calculator for rapid, quantitative analysis of electric logs has been developed by Dr. R. G. Hamilton, Hamilton Well Log Consultant, Tulsa, and J. J. Arps, Dallas.

The rule provides for automatic correction of all data and instantly solves all equations in the analysis of any of the various types of logs. Solved are quantitative as well as empirical relationships in deriving porosity, percent of water saturation and estimates of permeability.

The modernized rule, while fully comprehensive in its interpretations, meets the needs of both the beginner and the advanced log specialist because both generalized quanitative relationships and specialized equations having variable coefficients and exponents are provided. These are color-coded for easy reference.
For more data, circle **No. E26** on Readers' Service Card, last page this issue.

Gas Valve Lubricant

Molykote Type 1102, a gas valve lubricant, has been announced by The Alpha-Molykote Corporation. The new lubricant is a high-temperature, non-melting point grease fortified with highly purified molybdenum disulfide powder.

This grease is recommended for use as a lubricant for plug cocks of metal, plastics or glass on equipment where reliable lubrication in the presence of gases or liquids is required. It eliminates the gumming formations which usually cause valves to stick.
For more data, circle **No. E27** on Readers' Service Card, last page this issue.

New Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Readers' Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Safety Folder

Well Completions, Inc., has published a four-page bulletin entitled "Safety Precautions and Recommendations Used in Air and Gas Drilling Oil Wells." The bulletin's purpose is to provide an outline for the schooling of rig personnel in safety habits during air or gas drilling operations.

To get a copy, circle **No. E28** on Readers' Service Card, last page this issue.

Mobile Rig Brochure

Highly mobile, wheel-mounted rigs are featured in a new bulletin released by Ideco, Inc., one of the Dresser Industries. Principal features of the dual rambler rigs are big-rig capacity with small-rig mobility.

To get a copy, circle **No. E29** on Readers' Service Card, last page this issue.

Influx Control Bulletin

How to control water influx encountered during air drilling is the subject of a new bulletin issued by Aquaness Dept., Atlas Powder Co. Describing the use of Afrox® foaming agents, the instructional bulletin embodies use of experience gained on 200-odd wells drilled during the past year with air or gas.

To get a copy, circle **No. E30** on Readers' Service Card, last page this issue.

Seal Folder

The new Oilmaster automatic top seal four-page bulletin from Fluid Packed Pump Co. includes descriptive data, pertinent design features, functional operation and parts listing.

To get a copy, circle **No. E31** on Readers' Service Card, last page this issue.

Well Stimulation Info

"Guides to Well Stimulation" is a new pamphlet prepared by Dowell Incorporated. It consists of a colored folder of Dowell treatment recommendations covering formations in Oklahoma, Kansas, Texas, New Mexico, Alabama and producing areas in Canada.

To get a copy, circle **No. E32** on Readers' Service Card, last page this issue.

Multi-Purpose Pump Folder

A complete line of condensate, turbine, boiler feed, centrifugal, proportioning and fuel oil pump and heater sets all of which are said to meet and exceed customers' requirements throughout many different industries are described and illustrated in a new bulletin recently released by Walter H. Eagan Company, Inc.

To get a copy, circle **No. E33** on Readers' Service Card, last page this issue.

Valve Use Bulletin

New data Unit No. 302 gives features, application information, pressure-temperature ratings and specifications of Jerguson valves for instrument piping and general use. This four-page catalog contains illustrations and sectional drawings showing how these valves combine unions, nipples, reducers, elbows, tees, valve and pressure bleeder valve in one space-saving unit.

To get a copy, circle **No. E34** on Readers' Service Card, last page this issue.

Ductile Iron Castings Info

The Acme Foundry & Machine Co., recently started the production of ductile iron castings.

Ductile iron represents a comparatively new family of cast metals which combines the processing advantages of cast iron—low melting point, good fluidity and castability, excellent machinability and good wear resistance—with many of the engineering advantages of steel, including high strength, toughness, ductility and hardenability.

To get a copy, circle **No. E35** on Readers' Service Card, last page this issue.

Bulk Equipment Manual

A new 12-page catalog is available covering the complete line of bulk plants, bulk trucks and correlated equipment utilized in the oil well cementing field, mud service and general industrial bulk commodities. The new brochure also covers custom made trailer units and specialized fabrications for the refinery and pipe line field, with custom designed models for export shown.

To get a copy, circle **No. E36** on Readers' Service Card, last page this issue.

Solenoid Valve Pamphlet

New Bulletin 500 C includes pictures and description of Gould basic types of solenoid valves, covering a wide range of operating conditions. Special features are a line of stainless steel valves size ½-inch to 2 inches and the Type HV series having four independent controls for variable opening and closing speeds, flow control and manual opening.

To get a copy, circle **No. E37** on Readers' Service Card, last page this issue.

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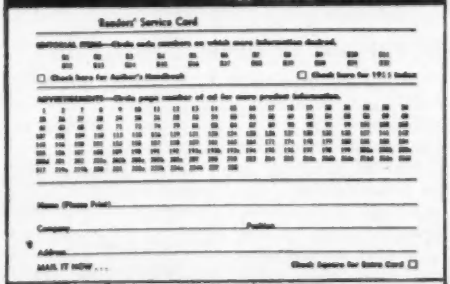

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